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RECORDS OF THE AUSTRALIAN MUSEUM

TEREBELLIFORM POLYCHAETA

P. A. HUTCHINGS

PONTONIINE SHRIMPS IN THE AUSTRALIAN MUSEUM

A. J. BRUCE

LEAFHOPPERS AND FROGHOPPERS

J. W. EVANS

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TEREBELLIFORM POLYCHAETA OF THE FAMILIES AMPHARETIDAE, TEREBELLIDAE AND TRICHOBRANCHIDAE FROM AUSTRALIA, CHIEFLY FROM MORETON BAY, QUEENSLAND.

PAT HUTCHINGS,

The Australian Museum, Sydney

SUMMARY

Some 24 species of polychaetes of the Terebelliformia group are recorded from Moreton Bay, Queensland, and previous records from Australia are reviewed. In the Ampharetidae one new genus, new species is established *Pseudoamphicteis papillosa* as well as a new species of *Auchenoplax, A. mesos.* In the Terebellidae, four new genera, new species are established: *Decathelepus ocellatus, Hadrachaeta aspeta, Litancyra octoseta* and *Rhinothelepus macer,* as well as three new species of *Pista: P. pectinata, P. trunca* and *P. trina. Artacamella dibranchiata* Knox and Cameron is redescribed and newly assigned to Trichobranchidae.

INTRODUCTION

The major portions of the terebelliform polychaetes were collected in connection with a two year ecological study, in 1970-1971, of the southern portion of Moreton Bay (Long. 153°15'E, Lat. 27°15'S) south of Peel Island, carried out by Professor Stephenson, and others, of the Zoology Department, Queensland University, and from the Middle Banks area off Tangalooma, in June to December 1972. Additional material from Moreton Bay was collected by Mrs C. Wallace, Queensland Museum. Wherever possible, material from other localities in Eastern Australia was examined in order to extend the range of the species found in Moreton Bay.

A total of 24 species are recorded from Moreton Bay, many of which are new to Queensland. Rullier was sent the collection of polychaetes from Moreton Bay that he reported on in 1965, by Stephenson, and the areas which these polychaetes were collected from were described by Stephenson, et *al.*, (1970). This survey indicated that an area south of Peel Island had a particularly rich fauna and this area was subsequently intensively sampled by Stephenson, et *al.*, (1974). This may explain the difference in the number of species of terebelliforn polychaetes that Rullier recorded (5) and the number described in this paper (24).

Some of the material was collected by Stephenson, and others, in a relatively small area south of Peel Island in the southern portion of Moreton Bay. Fifteen sites, in 2-8 metres, were sampled in quintuplicate and repeated at 3 month intervals, from March 1970 to December 1971. This area is figured by Stephenson, et *al.*, (1974). See Table 1.

Records of The Australian Museum, 1977, **Vol. 31 No. 1,** 1-38, Figures 1-13

Table 1. Station data for material collected in March 1970 to December 1971 by Stephenson from south of Peel Island, in southern part of Moreton Bay, Queensland

Area I-mud. 1 mile SE of SW rocks Peel Island.
Area II-shell, grit and sand. ½ mile S of SW rocks Peel Island.
Area III-sand, mud and shell. 1½ miles S of SW rocks Peel Island.

Depth of Stations

Area I	**Area II**	**Area III**
IA-6 m	IIA-6 m	IIIA-6 m
IB-5 m	IIB-7 m	IIIB-2 m
IC-4 m	IIC-7 m	IIIC-5 m
ID-4 m	IID-8 m	IIID-3 m
IE-4 m	IIE-8 m	IIIE-4 m

At each station, 5 samples were taken i.e., IIA1, IIA2, etc., every 3 months from March 1970-December 1971 inclusive.

In addition, some 52 stations were made in Moreton Bay in the area of Middle Banks off Tangalooma Point, in 5-18 metres, by Stephenson, and others in June, September and December 1972. See Figure 1. Sediments at all sampling sites were made up of coarse or medium sand (Stephenson, et al., 1970, figure 3).

The holotypes, part of the paratypes, and most of the other specimens are deposited in the Australian Museum (AM). Some paratypes and a small reference collection were sent to the Queensland Museum (QM). Additional paratypes are deposited in the British Museum (Natural History) (BMNH), and the Smithsonian Institution (USNM). Additional material was received on loan from the National Museum, Victoria (NMV), the Queensland Museum, the Zoologisk Museum, Bergen (ZMB) and Fisheries and Wildlife, Victoria (Marine Pollution Group) (FWV). The station data for sites sampled by Fisheries and Wildlife, Victoria, during the Port Phillip Bay Environmental Study, 1969-71, are given by Poore, Rainer and Spies, (1975).

Family **Ampharetidae** Malmgren, 1867

List of species reported from Australia

Subfamily *Melinninae*

Isolda pulchella Müller. Moreton Bay (Stephenson, et al., 1974). See below.

Isolda warnbroensis Augener, 1914. Warnbro Sound near Fremantle, SW Australia. See below under *I. pulchella*.

Subfamily Ampharetinae

Amphicteis gunneri (Sars). Moreton Bay (Stephenson, et al., 1974). Referred to *Pseudoamphicteis papillosa*. See below.

Amphicteis foliata Haswell, 1883. Bowen, Queensland. Referred to *Phyllamphicteis foliata* fide Augener, 1927.

Amphicteis philippinarum Grube. Cape Jaubert, NW Australia (Augener, 1922).

Amphicteis sp. Sydney, New South Wales (Hutchings and Recher, 1974).

Auchenoplax mesos n.sp. Moreton Bay. See below.

Auchenoplax sp. Moreton Bay (Stephenson, et al., 1974). Referred to *A. mesos* n. sp.

Lysippides sp. Sydney, New South Wales (Hutchings and Recher, 1974).

Phyllamphicteis foliata Haswell. Eden, New South Wales and Melbourne, Victoria (Augener, 1927).

Pseudoamphicteis papillosa n.g. n.sp. Moreton Bay. See below.

Rytocephalus ebranchiatus Quatrefages, 1865. Jervis Bay, New South Wales. Referred to *?Amphicteis ebranchiatus* — indeterminable fide Hartman, 1959.

Samytha sp. Sydney, New South Wales (Hutchings and Recher, 1974).

KEY TO THE SUBFAMILIES AND GENERA OF AMPHARETIDAE FROM AUSTRALIA

1. Segments III-V (or III-VI) with fine acicular neurosetae. No paleae. Post branchial hooks present ..... *Isolda* (Subf. Melinninae)
— Segments III-VI without neurosetae. No post branchial hooks. Paleae sometimes present ..... (Subf. Ampharetinae) 2

2.(1) Glandular ridges on prostomium 3
— No glandular ridges on prostomium 4

3.(2) Oral tentacles smooth ..... *Amphicteis*
— Oral tentacles papillose ..... *Pseudoamphicteis* n.g.

4.(3) Twelve uncinigerous thoracic segments ..... *Auchenoplax*
— Fourteen uncinigerous thoracic segments ..... *Phyllamphicteis*

Subfamily **Melinninae**
Isolda Müller, 1858

DIAGNOSIS: Oral tentacles smooth. Four pairs of gills, 2 pairs smooth, 2 pairs pinnate. Dorsal crest across segment VI. Segments III, V and VI with notopodial capillaries, segment IV with notopodial hooks. Fine acicular neurosetae on segments III-V. Thoracic uncini with a single row of teeth.

Isolda pulchella Müller, 1858

Isolda pulchella. — Augener, 1918: 517, pl. 7, fig. 229, text fig. 88. — Day, 1963: 434-435; 1967: 691-692, fig. 35.1 k-n; 1973: 113, fig. 15d-f. — Stephenson, et al., 1974: 114.

Isolda warnebroensis Augener, 1914: 82, pl. 1, figs. 14-15, text fig. 13a-c.

Isolda sibogae Caullery, 1944: 102, fig. 83A-H.

MATERIAL EXAMINED: Queensland — Moreton Bay, south of Peel Island, Stephenson, et al., coll., St. II E2. June 1971, 8 m; St. III A3/D1/E3, June/Sept. 1971, 3-6 m. 4 spec. (AM).

DESCRIPTION: Compact prostomium. Oral tentacles smooth with groove along one side. Gills in two groups of 4, inner 2 pairs with 2 rows of long lateral pinnules, outer 2 pairs smooth. Fine acicular neurosetae on segments III-V. Stout notopodial hooks on segment IV. Small notopodial capillaries on segments V and VI. Uncini start on segment VII, 13 thoracic uncinigerous segments, and more than 30 abdominal uncinigerous segments. Uncini with

single vertical series of 5-6 teeth, and a small rostral point and projecting basal prow. Abdominal uncini on square tori, with small rudimentary notopodial pinnule above. Preserved specimens colourless.

REMARKS: The specimens from Moreton Bay agree in all respects with the descriptions given by Day except that the buccal tentacles (dissected) have no colour patterns.

DISTRIBUTION: Australia; South Africa; North Carolina, USA; Brazil; Indonesia.

Subfamily **Ampharetinae**

Auchenoplax Ehlers, 1887

DIAGNOSIS: Prostomium without dorsal glandular ridges. Oral tentacles smooth with a groove along one side. Two pairs of gills. Segments III-VI without neurosetae. Segments V and VI with notopodial capillaries. Twelve uncinigerous thoracic segments and about 12-15 abdominal ones. First row of thoracic uncini on segment VII very long. Thoracic uncini with 1 or 2 series of teeth. Notopodial cirri present.

Auchenoplax mesos n.sp.
Fig. 2a-c

Auchenoplax (sic) sp. Stephenson, et al., 1974: 114.

MATERIAL EXAMINED: Queensland — Moreton Bay, south of Peel Island, Stephenson, et al., coll., St. IB5, June 1970, 5 m — holotype (AM W.6780).

Size — holotype, complete specimen 15 mm long, 2 mm wide.

DESCRIPTION: Prostomium a pointed triangular cone, with ventrally a pair of shallow lateral, slightly diverging grooves. Prostomium and peristomium almost completely fused forming a flattened shield like structure, ornamented with narrow vertical grooves. Withdrawn oral tentacles dissected, smooth. Eye spots and pigmentation patterns absent. Paleae and post branchial hooks absent. Eight gill scars arranged in 2 groups of 2 pairs, across a slightly elevated fold. Large median gap between right and left pairs of gill scars, posterior pair slightly displaced ventrally. The one remaining simple gill became detached during examination. Fourteen pairs of notopodia from segment 5, with smooth tipped capillary notosetae. Notopodial cirri absent (fig. 2b). Neuropodial uncini begin on 3rd setigerous segment (segment 7), and continue to last abdominal segment. First row of uncini slightly displaced ventrally but second row much longer, almost midventral in position. Third and subsequent rows, much shorter, arranged laterally, adjacent to notopodia. Uncini arranged in single rows; each uncinus has two vertical rows of teeth, each row consisting of four teeth. Small basal denticle present between 2 rows of teeth. Apical denticle absent (fig. 2c). Abdominal uncini borne on projecting leaf-shaped pinnules, which become more prominent on posterior abdominal segments. Abdominal uncinigerous pinnules occur on longitudinal glandular strips, and appear as rows of beads along sides of abdomen.

Ventral pads absent. Anterior ventral margins of segments slightly elevated and glandular particularly on anterior thoracic segments. Nephridial papillae occur on notopodia of setigers 5-8. Thirteen abdominal segments. Pygidium lacks anal cirri. Lives in flimsy mucous tube sparsely covered with sand grains.

REMARKS: *Auchenoplax mesos* differs from *A. crinita* Ehlers, the only previously-described species in this genus, in the shape and dentition of the uncini. *A. crinita* has 2 rows of lateral teeth plus a median and a basal tooth, and the uncini are shorter than those of *A. mesos*. *A. crinita* has been recorded from deep water, 540 and 572 m in Florida Straits off New England (Hartman, 1965a); off Beaufort, North Carolina in 600 m (Day, 1973); North eastern South America and off Morocco in 200-1000 m, whereas *A. mesos* was found in 5 m.

Day (1964), questionably referred *Melinnoides* Benham, 1927 to *Auchenoplax* Ehlers, 1887. Benham described the only species of this genus, *M. nelsoni* from McMurdo Sound in 200 m, and again the uncini differ from those of *A. mesos*. *M. nelsoni* does not have 1 or 2 rows of uncini displaced ventrally like *Auchenoplax* and perhaps *Melinnoides* should not be synonymised with *Auchenoplax*. *Auchenoplax mesos* is therefore described as a new species and represents the first record of this genus from Australia.

Pseudoamphicteis n.g.

DIAGNOSIS: Prostomium with pair of glandular ridges. Papillose buccal tentacles, grooved along one side. Two pairs of simple gills on either side of segment 3. Segment 3 with paleae, segments 4-6 with notopodial capillaries. Segments 3-6 without neurosetae. Fourteen uncinigerous thoracic segments. Notopodial cirri present. Thoracic uncini with single vertical series of teeth. Abdominal segments with uncinigerous pinnules and notopodial cirri.

Type species **Pseudoamphicteis papillosa** n.sp., by present designation

Pseudoamphicteis papillosa n.g., n.sp.
Fig. 3a-e

Amphicteis gunneri. — Stephenson, et al., 1974: 114. Not Sars, 1835.

MATERIAL EXAMINED: Queensland — Moreton Bay, Stephenson, et al., south of Peel Island, St. IIC1, Sept. 1970, 7 m — paratype (USNM 52620); St. IID1, Sept. 1970, 8 m — holotype (AM W. 6781); St. III C2/C3, Mar./Sept. 1970, 5 m — 3 spec., (AM W. 6799/6800). Middle Banks off Tangalooma, St. 21, June 1972 — paratypes (QM G.8160; BMNH, ZB 1975-133-138). Port Molle — 1 spec., (AM G. 11277).

Size — holotype, 18 mm long, width at anterior end 3 mm. Length of paratypes 15-24 mm, width at anterior end 1.5-3 mm.

DESCRIPTION: Prostomium spathulate with pair of prominent straight glandular ridges, flared at tips extending onto peristomium. Oral tentacles of 2 kinds, one with 2 distinct rows of fine papillae on one side, others smooth found dorsally around the base of papillose tentacles, which are dominant. Eye spots absent. First 2 segments achaetous. Third segment with two groups of 9-10 paleae. Paleae are straight, stout, narrow winged with slightly curved tips. Two pairs of simple, stout, free unbranched gills on either side of segment III (total of 8 gills), all with slightly bulbous bases. Gills arranged in 2 tiers with distinct median gap between right and left pairs of gills; arise from margin of posterior branchial ridge on segment III, forming slight pocket. Post branchial hooks absent. Notosetae begin on segment IV, continue for 17 segments, and are smooth tipped, pointed, winged capillaries (fig. 3b). Notopodia of segments IV and V small. Neuropodial uncini begin on 4th setigerous segment (segment 7) and continue for 14 thoracic segments. Thoracic uncini arranged on elevated ridges, and abdominal ones on small elevated rectangular pinnules, occurring in single rows throughout. Uncini with a single row of 5 teeth (fig. 3c, d). All neuropodia and thoracic notopodia have well developed cirri; abdominal notopodia with rudimentary cirri, but totally lacking notosetae. Ventral glandular pads absent, although individual segments glandular especially the antero-ventral margins of segments. Distinct ventral median glandular streak on posterior thorax and abdomen. Pygidium has 4 anal cirri. Holotype has nephridial papillae on setiger 4.

REMARKS: This new genus closely resembles the genus *Amphicteis*, in having glandular ridges on the prostomium, 14 uncinigerous segments, 4 pairs of smooth gills and notopodial cirri, but differs in that the oral tentacles are predominantly papillose and not smooth as in *Amphicteis*. Day, in his revision of the Ampharetidae (1964), gives a summary of generic characteristics used in their classification, which includes the ornamentation of buccal tentacles, and later (1967), he used this in his key, so that this species cannot be grouped with

Amphicteis. Similarly other genera, such as *Ampharete, Asabellides, Pseudosabellides, Sabellides,* and *Pterampharete* which have papillose oral tentacles, cannot be grouped with this new species, as they differ in other important generic characteristics, as defined by Day (1964). For this reason a new genus is created, *Pseudoamphicteis*.

As ampharetids are regularly preserved with their oral tentacles completely withdrawn, it is possible that some described species of *Amphicteis have papillose oral tentacles, and they should be removed to the genus Pseudoamphicteis.*

Family **Terebellidae** Grube, 1851

List of species reported from Australia.

Subfamily *Polycirrinae*

Amaeana trilobata (Sars). Moreton Bay (Stephenson, et al., 1974). See below.

Litancyra octoseta n.g., n.sp. Moreton Bay. See below.

Lysilla apheles Hutchings, 1974. Wallis Lake, New South Wales.

Lysilla pacifica Hessle. Sydney, Wallis Lake, New South Wales (Hutchings 1974; Hutchings and Recher, 1974). See below.

Lysilla sp. Moreton Bay (Stephenson, et al., 1974). Referred to *Lysilla apheles*. See below.

Polycirrus boholensis Grube. West Australia (Augener, 1914). ? Moreton Bay (Rullier, 1965) not Grube, referred to *Lysilla apheles*. See below.

Polycirrus porcata Knox and Cameron, 1971. Port Phillip Bay, Victoria.

Subfamily **Thelepinae**

Decathelepus ocellatus n.g., n.sp. Moreton Bay. See below.

Rhinothelepus lobatus Hutchings, 1974. Wallis Lake, Sydney, New South Wales (Hutchings and Recher, 1974).

Rhinothelepus macer n.sp. Moreton Bay. See below.

Streblosoma amboinense Caullery. Wallis Lake, New South Wales (Hutchings, 1974). See below.

Streblosoma gracile Caullery. Moreton Bay (Stephenson, et al., 1974). See below.

Streblosoma sp. Moreton Bay (Stephenson, et al., 1974). Referred to *S. amboinense*. See below.

Telothelepus sp. Moreton Bay (Stephenson, et al., 1974). Referred to *Decathelepus ocellatus*. See below.

Thelepus plagiostoma (Schmarda). W and NW. Australia (Augener, 1914); Moreton Bay (Rullier, 1965). See below.

Thelepus robustus (Grube). Moreton Bay, new record from Australia. See below.

Thelepus setosus (Quatrefages). South Australia (Fauvel, 1917); Port Phillip Bay, Victoria (Knox and Cameron, 1971); Sydney, New South Wales (Hutchings and Recher, 1974).

Thelepus thoracicus Grube. SW and NW Australia (Augener, 1914, 1922). Referred to *T. setosus* by Fauvel, 1917.

Subfamily **Amphitritinae**

Amphitrite modesta (Quatrefages). See below under *Terebella modesta*.

Amphitrite rubra (Risso). St. Vincent's Gulf, South Australia (Fauvel, 1917); Moreton Bay (Rullier, 1965; Stephenson, et al., 1974); Port Phillip Bay, Victoria (Knox and Cameron, 1971). See below.

Amphitrite vigintipes Marenzeller. Victoria (Augener, 1927). See below under *A. rubra*.

Axionice harrisoni (Benham). Port Phillip Bay, Victoria (Knox and Cameron, 1971).

Eupolymnia nebulosa (Montagu). Port Phillip Bay, Victoria (Knox and Cameron, 1971).

Hadrachaeta aspeta n.g., n.sp. New South Wales, Moreton Bay, Queensland. See below.

Lanice conchilega (Pallas). Port Phillip Bay, Victoria (Knox and Cameron, 1971); New South Wales — tube only (Augener, 1927); Moreton Bay (Stephenson, et al., 1974). See below.

Leprea haplochaeta Ehlers. Rottnest Island, S.W. Australia (Augener, 1913, 1914). Referred to *Terebella haplochaeta* by Hartman, 1959.

Loimia nr. ingens (Grube). Sydney, New South Wales (Hartman, 1966). See below under *L. ingens*.

Loimia ingens (Grube). Moreton Bay (Stephenson, et al., 1974). See below.

Loimia medusa (Savigny). N.W. Australia (Augener, 1922); Sydney, New South Wales (Augener, 1927); Moreton Bay (Rullier, 1965; Stephenson, et al., 1974). See below.

Loimia montagui (Grube). N. Queensland (Monro, 1931). Referred to *L. medusa* by Rullier, 1965.

Nicolea cetrata (Ehlers). Westernport, Victoria (Augener, 1927). Referred to *Pista cetrata* by Augener, 1927, Day, 1967.

Pista pectinata n.sp. Moreton Bay. See below.

Pista trina n.sp. Moreton Bay. See below.

Pista trunca n.sp. Moreton Bay. See below.

Pista typha Grube. Eden, New South Wales (Augener, 1927); Low Isles, Great Barrier Reef (Monro, 1931); Port Phillip Bay, Victoria (Knox and Cameron, 1971); Moreton Bay (Stephenson, et. al., 1974). See below.

Pista sp. 1. Moreton Bay (Stephenson, et al., 1974). Referred to *P. pectinata*. See below.

Pista sp. 2. Moreton Bay (Stephenson, et al., 1974). Referred to *P. trunca*. See below.

Pista sp. 3. Moreton Bay (Stephenson, et al., 1974). Referred to *P. trina*. See below.

Polymnia nebulosa (Montagu). Spencers Gulf, South Australia (Fauvel, 1917). Referred to *Eupolymnia nebulosa* by Hartman, 1959.

Polymnia trigostoma (Schmarda, 1861). New South Wales; West Australia (Augener, 1914); Bowen, Queensland (Augener, 1922); Westernport, Victoria (Augener, 1927). Referred to *Eupolymnia trigostoma* by Hartman, 1959.

Reteterebella queenslandia Hartman, 1963. Heron Island, Queensland.

Scione harrissoni Benham, 1916. Off Kingston, South Australia. Referred to *Axionice* by Knox and Cameron, 1971.

Terebella (Lanice) flabellum Baird, 1864. Sydney, New South Wales. Referred to *Lanice flabellum* by Hartman, 1959.

Terebella grubei McIntosh, 1885. Two Fold Bay, Sydney, New South Wales. Referred to *Eupolymnia trigonostoma* by Hartman, 1959.

Terebella modesta Quatrefages, 1865. Jervis Bay, New South Wales (Whitelegge, 1889). Referred to *Amphitrite modesta by Hartman, 1959.*

Terebella ochracea Grube, 1878. N.W. Australia.

Terebella stenotaenia Grube, 1871. Moreton Bay, Queensland.

Terebella trigonostoma Schmarda, 1861. New South Wales.

KEY TO THE SUBFAMILIES AND GENERA OF TEREBELLIDAE FROM AUSTRALIA

1.	Gills absent ..... (Subf. Polycirrinae)	2
	Gills present	5
2.(1)	Neuropodial uncini absent	3
	Neuropodial uncini present	4
3.(2)	Abdomen with acicular notosetae ..... *Amaeana*	
	Abdomen without notosetae ..... *Lysilla*	
4.(2)	Avicular uncini ..... *Polycirrus*	
	Long-handled uncini ..... *Litancyra* n.g.	
5.(1)	Gills, simple, filamentous ..... (Subf. Thelepinae)	6
	Gills, branched ..... (Subf. Amphitritinae)	8
6.(5)	Notosetae start on segment 2 (1st branchiferous) ..... *Streblosoma*	
	Notosetae start on segment 3 (2nd branchiferous)	7
7.(6)	Uncini from setiger 3 ..... *Thelepus*	
	Uncini from setiger 6 ..... *Rhinothelepus*	
	Uncini from setiger 10 ..... *Decathelepus* n.g.	
8.(5)	Notosetae smooth-tipped	9
	Notosetae serrated	14
9.(8)	Uncini of first few uncinigerous segments different from following ones (base of uncinus extended posteriorly as long shaft) ..... *Pista*	
	All thoracic uncini similar	10
10.(9)	Gills, 1 pair present ..... *Axionice*	
	Gills, 2 or more pairs	11
11.(10)	Uncini avicular with close set arcs of denticles above main fang	12
	Uncini pectiniform with single vertical series of teeth ..... *Loimia*	
12.(11)	Uncini from thoracic setiger 1 (segment 4) ..... *Reteterebella*	
	Uncini begin thoracic setiger 2 (segment 5)	13

13.(12) Uncini set back to back on posterior segments ..... *Lanice*
Uncini not set back to back ..... *Eupolymnia*

14.(8) Uncini all avicular 15
Uncini, long handled hooks on setigers 2-5, following ones avicular .....
..... *Hadrachaeta*

15.(14) Lateral lobes present on segments 2, 3 and often 4 ..... *Amphitrite*
Lateral lobes absent ..... *Terebella*

Subfamily **Polycirrinae**
Amaeana (Hartman, 1959)

DIAGNOSIS: Tentacular lobe expanded and tre-foiled, with anterior tongue like lobe, posterior frilled portion with numerous short tentacles. Gills absent. Notosetae start on segment 3, continue for 10-13 thoracic segments. Thoracic neuropodia and neurosetae absent. About five achaetous segments between thorax and abdomen. Abdominal notopodia, with acicular notosetae. Abdominal neuropodia and neurosetae absent. Body swollen anteriorly. Ventral pads restricted to a groove.

Amaeana trilobata (Sars, 1863)

Amaea trilobata. — Fauvel, 1927: 285-286, fig. 99a-e.
Amaeana trilobata. — Day, 1967; 718-719, fig. 36.3 e-h; 1973: 122, fig. 16d-f. — Stephenson, et al., 1974: 113.

MATERIAL EXAMINED: Queensland — Moreton Bay, off Tangalooma Point, Stephenson, et al., coll., St. 5/7/23/25/30/32/35/40/41/47/51/53, Sept./Dec. 1972. Moreton Bay, south of Peel Island, Stephenson, et. al., coll., St. IA1/A2/A4/A5/B3/D2/D3/D5, March 1970/ June/July 1971, 4-6 m; St. II C3/E1, Dec. 1971, 7-8 m; St. III A3/B2/B5/C2/D1/D5, June/ Sept. 1971, 2-6 m (AM). Kangaroo Island, Mary River, Dec. 1971, Hutchings, coll., (AM W. 5384). Victoria — Port Phillip Bay Environmental Study 1969-1971, St. — 932/122, (FW V. 2520/5041).

DESCRIPTION: Body swollen anteriorly, with glandular areas around thoracic notopodia. Thoracic notopodia, long slender, 10 pairs with fine smooth winged capillary notosetae. Small distinct nephridial papilla at base of each thoracic notopodium. Gonopores on thoracic segments in mature specimens. Five to six achaetous segments between thorax and abdomen. Abdomen with 30-40 pairs of notopodia, five to six, straight acicular notosetae with blunt tips, per notopodia. Colour purple in life.

REMARKS: The specimens from Moreton Bay tend to have more abdominal uniramous segments than indicated by Day (1967), but these specimens were generally larger than those found by Day.

DISTRIBUTION: Australia; Arctic; Norway; North Carolina, U.S.A.; Mediterranean; South Africa; Japan; Solomon Islands.

Litancyra n.g.

DIAGNOSIS: Tentacular lobe, long and expanded. Thoracic notosetae, 8 pairs with frayed tips, beginning on segment 2. Gills absent. Uncini long-handled hooks, restricted to abdomen, borne on elevated tori. Ventral pads absent.

Type species **Litancyra octoseta** n.sp., by present designation

Litancyra octoseta n.g., n.sp.

Fig. 4a-d

MATERIAL EXAMINED: Queensland — Moreton Bay, Wallace, coll., dredged from Serpentine Creek, St. 25, Sept. 1972, 2 m, sandy, 2.1 km upstream — holotype (AM W.6825). New South Wales — Belmont Beach, Laxton, coll., grabbed Aug. 1972, 22 m — paratype (AM W.8127).

Size — holotype, complete specimen, 9 mm long, width at anterior end 1 mm, paratype, complete specimen, 38 abdominal segments, 21 mm long, width at anterior end 2 mm.

DESCRIPTION: Long expanded tentacular lobe forming tongue-like extension with large number of tentacles, varying considerably in size, largest at tip of tongue. Eyespots absent. Gills absent. Prominent projecting notopodia, 8 pairs, beginning on segment 2 (fig. 4b). Notosetae narrow winged capillaries, with frayed tips (fig. 4c). No thoracic uncini. Uncini present on all abdominal segments in single rows on projecting tori. Uncini protruding some distance beyond tip of torus, small, long handled, with several rows of teeth above main fang. No colour patterns on preserved specimen.

Ventral surface of body slightly glandular especially ventro-laterally with ill-defined mid-ventral streak. Mature holotype full of eggs, but nephridiopores not visible.

REMARKS: *Litancyra* is placed in the Polycirrinae as it lacks gills and has an expanded tentacular lobe. The classification of the terebellids, established by Hessle (1917), in which all abranchiate genera with uncini arranged in single rows are placed in the Polycirrinae, was followed by Fauvel (1927) and Hartman (1959), and adopted here. This is in contrast to that adopted by Day (1967), in which all abranchiate genera, regardless of the arrangement of uncini, are placed in the Polycirrinae.

Within the Polycirrinae (after Hessle *sensu stricto*) all genera have an expanded tentacular lobe. Most of the genera have uncini although they may be completely absent (e.g. *Hauchiella, Lysilla* and *Amaeana*), or restricted to posterior segments (e.g. *Polycirrus*). *Litancyra* differs from the previously described genera by having long-handled uncini, although many of the genera have uncini which closely resemble those of *Litancyra;* they only lack the shaft. Finally, *Litancyra* lacks well defined ventral pads, characteristic of Polycirrinae (*sensu stricto*).

Lysilla Malmgren, 1866

DIAGNOSIS: Tentacular lobe expanded, frilly with numerous tentacles around basal margins. Gills absent. Notopodia with notosetae, begin on segment 3, continue for 6-12 segments. Neuropodia and neurosetae absent. Ventral pads narrow, restricted to groove.

KEY TO SPECIES RECORDED FROM AUSTRALIA

Notosetae, simple capillaries ..... *L. apheles*
Notosetae barbed ..... *L. pacifica*

Lysilla apheles, Hutchings, 1974

Lysilla apheles Hutchings, 1974: 190-191, fig. 5.
(?) *Polycirrus boholensis.* — Rullier, 1965: 196. Not Grube, 1878.

MATERIAL EXAMINED: Queensland — Moreton Bay, Stephenson, et al., coll., south of Peel Island, St. IA5, June 1971, 6 m. Middle Banks off Tangalooma, St. 46/47/54, Sept./Dec. 1972 (AM). F.C.V., coll., Victoria Point, June 1962, Dunwich, midshore, May 1962 (QM).

DESCRIPTION: Short fat swollen body. Ten thoracic notopodia with simple smooth capillary setae, with finely serrated tips. Neurosetae absent. Nephridial papillae present on all setigerous segments, best developed on middle segments. Ventral surface glandular, covered in small warts.

REMARKS: Larger specimens collected in June and September were mature and full of large oocytes, with well developed nephridiopores. Smaller specimens collected in September and December had poorly developed nephridiopores, indicating that size of nephridiopores is not a useful specific character, although it has been used for this genus in the past.

DISTRIBUTION: Australia.

Lysilla pacifica Hessle, 1917

Lysilla pacifica Hessle, 1917: 232-233, fig. 66. — Imajima and Hartman, 1964: 348. — Hutchings, 1974: 191.

MATERIAL EXAMINED: Queensland — Moreton Bay, Stephenson, et al., coll., Middle Banks off Tangalooma, St. 12/28/29/51/, May/Sept./Dec. 1972 (AM).

DESCRIPTION: Short, fat, swollen thorax and tapering abdomen. Thoracic notopodia, 9-12 pairs with barbed notosetae. Thoracic neuropodia and neurosetae absent. Abdomen asetigerous. Nephridiopores present on all setigerous segments, but individuals vary in their development.

DISTRIBUTION: Australia; Indonesia; South Africa; Japan.

Subfamily **Thelepinae**

Decathelepus n.g.

DIAGNOSIS: Elongated tentacular lobe, numerous simple unbranched gills on segments 2 and 3. Smooth tipped notosetae from segment 3, 15 pairs. Neuropodial uncini from setiger 10 (segment 12), continue onto abdomen. Uncini short based, with subterminal dorsal button just behind prow. Lateral lobes absent.

Type species **Decathelepus ocellatus** n. sp., by present designation

Decathelepus ocellatus n.g., n.sp.

Fig. 5a-d

MATERIAL EXAMINED: Queensland — Moreton Bay, Stephenson, et al., coll., south of Peel Island, St. III E5, Sept. 1971, 4 m — holotype (AM W.6782).

Size — 10 mm long, 2 mm wide at anterior end, complete thorax and 3 abdominal segments.

DESCRIPTION: Expanded ventral tentacular lobe, convoluted expanded margins forming a tongue. Numerous grooved tentacles at base of tentacular lobe. Two discrete elongated patches of dorsolateral eye spots. Numerous simple gill filaments, segments 2-3. Approximately 10 gill filaments in each group on segment 2, and 7 filaments on segment 3, with median gap between groups. Gill filaments on segment 2, slightly longer and thicker than those on segment 3. Notosetae start on segment 3 (2nd branchiferous) 15 pairs, of smooth tipped, narrow winged, capillary setae varying in length within each bundle (fig. 5c).

Uncini from setiger 10 and continue posteriorly. Uncini minute, arranged in single rows. Long rows of abdominal uncini on sessile pinnules, at least on 3 remaining abdominal segments. Uncini with an elongated base and subterminal button, with main fang plus 3 rows of teeth above, with 5, 6 and 5-7 teeth respectively (MF:5:6:5-7). Prominent nephridial papillae on setigers 3-5. Lateral lobes absent. Distinct ventral glandular pads absent, individual segments glandular. Anterior margins of early thoracic segments elevated as thickened ridges. Indistinct ventral glandular strip extends posteriorly from mid thorax.

REMARKS: This new genus clearly belongs to the Thelepinae, as it has simple, unbranched gill filaments and the characteristically shaped uncini. Several genera have been described in this subfamily and they are differentiated mainly by the segment on which the noto and neurosetae begin. Other points, such as the presence or absence of lateral lobes and the expansion of the tentacular lobe are also used, but the author considers these to be less important. Since none of the described genera have uncini beginning on setiger 10, a new genus *Decathelepus*, has been erected. It is similar to *Parathelepus* Caullery, which has uncini beginning on setiger 9, but this genus has a compact tentacular lobe. An elongated tentacular lobe is also present in *Telothelepus* Day and *Rhinothelepus* Hutchings. These genera have uncini either completely absent from the thorax or else beginning on setiger 6. The Thelepinae should, however, be re-examined to determine the validity of the distribution of thoracic setae as a generic attribute.

Rhinothelepus Hutchings, 1974

DIAGNOSIS: Elongated tentacular lobe with numerous oral tentacles. Gills on segments 2-3, simple gill filaments. Notosetae start on segment 3, 15 pairs smooth tipped capillaries. Uncini from setiger 6, continue onto abdomen. Uncini short based with subterminal button. Lateral lobes absent.

KEY TO SPECIES RECORDED FROM AUSTRALIA

1. First 2 pairs of notosetae displaced dorsally ..... *R. macer* n. sp.
— First 2 pairs of notosetae not displaced dorsally ..... *R. lobatus*

Rhinothelepus macer n.sp.
Fig. 6a-c

MATERIAL EXAMINED: Queensland — Moreton Bay, Stephenson, et al., coll., Middle Banks off Tangalooma, St 1/12/14/19/21/23/24/27/30/32/36/41, Sept./Dec. 1972 — holotype (AM W. 6783), 3 paratypes (QM G. 8161), 5 paratypes (BMNH, ZB. 1975-140-145), 5 paratypes (USNM 52622), 19 paratypes (AM W. 6784-6792).

Size — holotype (incomplete posteriorly) 12 mm long, 1 mm wide, 37 segments, 20 of them abdominal. Paratypes (QM G. 8161) 1 complete, 32 mm long, 1 mm wide, 2 others (incomplete posteriorly), 27 segments. Paratype (BMNH, ZB. 1975-140-145), 5 specimens (incomplete posteriorly). Paratype (USNM 52622) 5 specimens (incomplete posteriorly). Paratypes (AM W. 6784-6792) 16 specimens (incomplete posteriorly).

DESCRIPTION: Tentacular lobe expanded ventrally, convoluted margins forming shield-like projection. Numerous small grooved tentacles at base of tentacular lobe. Two discrete patches of eye spots on dorsal surface of prostomium. Simple gill filaments on segments 2

and 3, arranged almost in straight transverse row. Ten gill filaments on each segment (2,3), small median gap between left and right pairs of gills. Lateral lobes absent. Notosetae begin on 2nd branchiferous segment (segment 3), displaced posteriorly to the gills and continue for 15 segments. Notosetae smooth tipped winged capillaries, wings much wider basally (fig. 6b), arranged in 2 tiers. First 2 pairs of notopodia displaced dorsally with following ones found in typical position. Uncini begin on 6th setiger (segment 8) and continue to pygidium. Thoracic uncini arranged in single rows; abdominal uncini borne on rectangular pinnules, with margins free of body wall. Uncini small, elongated, with subterminal button (fig. 6c). The uncini have a main fang with 3 rows of teeth above, with 4 or 5 and 6 and an indeterminate number of teeth respectively (MF: 4-5:6:∞). Distinct ventral pads absent, individual segments glandular and finely mottled. Indistinct ventral groove on posterior part of thorax. Nephridial papillae not visible. Preserved specimens small, pale and translucent. Some individuals mature with eggs. Lives in flimsy sandy tube.

REMARKS: *Rhinothelepus macer* is placed in the genus *Rhinothelepus* Hutchings based on the extended tentacular lobe, simple gill filaments on segments 2 and 3, notosetae beginning on segment 3 and continuing for 15 segments, and uncini beginning on segment 8 (setiger 6). *Rhinothelepus macer* differs from the other described species in the genus *R. lobatus* Hutchings by having fewer gill filaments with an almost non-existent gap between them, and the first 2 pairs of notosetae being displaced dorsally. In *R. lobatus* the abdominal uncini are borne on thick, partially elevated triangular portions of the body wall, whereas in *R. macer*, the uncini are borne on distinct pinnules which are free of the body wall. The uncini of *R. macer* have a more elongated base and a distinct subterminal button on the prow, in comparison to *R. lobatus*. At the present time this genus has only been recorded from Australia.

Streblosoma Sars, 1872

DIAGNOSIS: Tentacular lobe short and compact, numerous oral tentacles. Nil to 3 pairs of gills on segments 2-4, unbranched filamentous. Notosetae start on segment 2 (1st branchiferous), smooth tipped capillary notosetae. Uncini start on segment 5 (setiger 4).

KEY TO SPECIES RECORDED FROM AUSTRALIA

1. Notosetae range from 24-29 pairs ..... *S. amboinense*
   Notosetae exceed 50 pairs ..... *S. gracile*

Streblosoma amboinense Caullery, 1944

Streblosoma amboinense Caullery, 1944: 180-181, fig. 144A-D. — Hutchings, 1974: 191-192.

MATERIAL EXAMINED: Queensland — Moreton Bay, Stephenson, et al., coll., Middle Banks off Tangalooma, June 1972 — 2 spec. (no station data available) (AM).

DESCRIPTION: Three pairs of gills on segments 2-4, each of 10-12 simple filaments. Notopodia, 24-29 pairs, with 2 kinds of notosetae, long narrow winged capillaries with faintly striated edges, short smooth finely tapered winged capillaries. Uncini start on segment 5 (setiger 4), abdominal uncini borne on low uncinigerous ridges. Dental formulae of uncini MF:2:3, main fang with 2 rows of teeth above with 2 and 3 teeth respectively. Nephridial papillae present on setigers 2-4. Body and gills colourless in preserved specimens; in fresh material gills have green pigment.

REMARKS: Caullery (1944) in his original description did not indicate the number of pairs of notopodia although one of his specimens had more than 40 segments. It is not clear, therefore, whether Caullery's specimens had more than 40 pairs of notosetae, or less. The

specimens from Moreton Bay and those previously described from Wallis Lake, New South Wales (Hutchings, 1974) seem to vary in the number of pairs of notosetae. The type of *S. amboinense* should be examined, but at this stage the Australian specimens are referred to this species.

DISTRIBUTION: Australia; Indonesia.

Streblosoma gracile Caullery, 1944

Streblosoma gracile Caullery, 1944: 178, fig. 141 A-C. — Stephenson, et al., 1974: 113.

MATERIAL EXAMINED: Queensland — Moreton Bay, Stephenson, et al., coll., south of Peel Island, St. II A3, Sept. 1970, 6 m — 1 spec., (AM).

DESCRIPTION: Incomplete specimen of about 50 segments. Eye spots present. Three pairs of gills, each gill of first pair 6 filaments; second pair 4; third 2. Distinct median gap exists between left and right gills. Notosetae start on 1st branchiferous segment, present on all subsequent segments, notosetae winged capillaries with long smooth tapering points, about 10 equal length setae per bundle. Uncini start on setiger 4, always arranged in single rows. Abdominal uncini on narrow rectangular pinnules. Uncini with button placed just behind the prow, main fang with 2 rows of teeth above with 3 and 5 teeth respectively (MF: 3:5). No nephridial papillae visible. Ventral pads ill-defined but individual segments glandular. Indistinct longitudinal glandular streak on ventrum of posterior thorax and abdomen.

REMARKS: The specimens from Moreton Bay agree well with the description given by Caullery (1944), except for the presence of eye spots, but these can easily fade on preserved specimens. Also the specimens of Caullery's were collected from 535 m whereas those from Moreton Bay were collected at 6 m. However at this stage, the specimens from Moreton Bay are referred to *S. gracile*, although Caullery's material has not been examined.

The uncini from the Moreton Bay specimens resemble those figured by Day (1967, fig. 36: 5c, d) for *S. persica* (Fauvel), in having a well developed dorsal button slanting forwards and with the base having a well developed spur. Fauvel (1908, fig. 1) figures two uncini, both of which are more elongated than Day's, without a well developed spur or dorsal button. Day also states that *S. persica* has no eye spots, single type of notosetae, 3 pairs of gills numbering 6 filaments, and 13 well marked ventral pads. Fauvel's description states, several rows of eye spots, more spiral gill filaments than 6 and 2 types of notosetae present. The specimen from Moreton Bay does not therefore agree with the original description of *S. persica*, and is referred to *S. gracile*

DISTRIBUTION: Australia; Indonesia.

Thelepus Leuckart, 1849

DIAGNOSIS: Tentacular lobe short and collar like, usually with numerous eye spots. Gills on segments 2-4, numerous simple filaments arranged in transverse rows. Lateral lobes absent. Notosetae start on segment 3 (2nd branchiferous), continue for numerous segments, smooth tipped capillaries. Uncini from setiger 3, continue for numerous segments; avicular with prolonged base and attachment button on upper basal surface.

KEY TO SPECIES RECORDED FROM AUSTRALIA

1. Notosetae terminate halfway along abdomen ..... *T. setosus*
— Notosetae continue almost to pygidium 2

2.(1) Abdominal uncini and notosetae terminate on the same segment ..... *T. plagiostoma*
— Abdominal uncini and notosetae do not terminate on the same segment . ..... *T. robustus*

Thelepus plagiostoma (Schmarda, 1861)
Fig. 7a

Thelepus plagiostoma. — Augener, 1914: 95-98; 1922: 48. — Fauvel, 1919: 455, fig. 10. — Rullier, 1965: 196.

MATERIAL EXAMINED: Queensland — Moreton Bay, Dunwich mud flats, coll., 1950, mid tide level (QM); T.H. and party, coll., June 1962 (QM G.3976).

DESCRIPTION: Large species with over 150 segments. Three pairs of gills, numerous gill filaments. Notosetae continue almost to pygidium. Uncini in single rows, uncinigerous tori poorly developed. Abdominal notosetae and uncini terminate on same segment, 10-12 achaetous preanal segments.

DISTRIBUTION: Australia; South Africa; Madagascar; Red Sea; Japan; New Zealand; Chile; West coast of U.S.A.

Thelepus robustus (Grube, 1878)
Fig. 7b

Phenacia robusta Grube, 1878: 235-236, pl. 12, fig. 8.
Thelepus robustus. — Caullery, 1944: 166-167, fig. 131 A-F.
MATERIAL EXAMINED: Queensland — Moreton Bay, Pope, coll., Dunwich, Stradbroke Island, Aug. 1961, intertidal (AM W. 3731, 5103); Rat Island, Port Curtis, Ward and Boardman, coll., July 1929 (AM W. 2753); Thursday Island (AM G. 11199). New South Wales — Port Denison, Sydney, Rainford, coll., (AM W. 5102); Port Jackson, Sydney, Johnston, coll., (AM W. 5104).
DESCRIPTION: Compact prostomium with ring of eye spots. Gills, 3 pairs on segments 2-4, numerous simple gill filaments. Notosetae from 2nd branchiferous segment, continue almost to pygidium, smooth tipped winged capillary setae. Number of setae per bundle, reduced in posterior segments. Uncini from setiger 3, continue beyond notosetae. Uncini with prominent upturned terminal button. No nephridial papillae present.

REMARKS: Caullery (1944), states that eye spots are normally absent, although they are present on one of his specimens, and they are present on all specimens from Moreton Bay.

Both *Thelepus robustus* and *T. plagiostoma* occur in Moreton Bay. *T. robustus* can be distinguished from *T. plagiostoma* by the abdominal uncini not terminating on the same segment as the notosetae, whereas in *T. plagiostoma* they terminate on the same segment.

The uncini of *T. robustus* are also larger, their bases wider and less angular than those of *T. plagiostoma* (fig. 7a-b.).

DISTRIBUTION: Australia; Indonesia; Philippines.

Subfamily **Amphitritinae**
Amphitrite O.F. Müller, 1771

DIAGNOSIS: Tentacular lobe short and compact with numerous oral tentacles. Gills 2-3 pairs on segments 2-4, simple or branched filaments. Lateral lobes present on segments 2-4. Notosetae begin on 3rd branchiferous (segment 4), continue for 13-25 segments. Winged capillary notosetae with finely serrated tips. Avicular uncini from setiger 2, in posterior thorax arranged in double or alternating rows. Well developed ventral pads.

Amphitrite rubra (Risso, 1828)

Amphitrite rubra. — Fauvel, 1917: 265-267, fig. 27; 1927: 249-250, fig. 85h-l. — Rullier, 1965: 195. — Knox and Cameron, 1971: 36 (part).
Amphitrite vigintipes. — Augener, 1927: 247-248.

MATERIAL EXAMINED: Queensland — Moreton Bay, Stephenson, et al., coll., south of Peel Island, St. III B4/D1, June 1970/Sept. 1971, 2-3 m (AM). Dredged west side of Moreton Island, 34 m, dredged off S. of Moreton Island, 25 m, May 1961; dredged SW of M3 red beacon, Nov. 1961 (QM) (Rullier, determined, 1965). Victoria — Port Phillip Bay, Environmental Study, 1957-1963, many areas (NMV G. 1682/1706/1708/1714/1716/1718/1719/1721/1815/1816/1817/1819/1822/1837/1841/1842/1856/1857/1858/ (Knox and Cameron, determined, 1971).

DESCRIPTION: Compact prostomium. Eye spots absent. Three pairs, well developed dichotomously branched gills on segments 2-4. Lateral lobes on segment 2, small, partially enclosing tentacles, segment 3, with lobes forming a semicircular flap, and segment 4 with small thickened anterior margins. Notopodia present from segment 4 (3rd branchiferous) continue for 22-24 segments. Notosetae winged capillaries with finely serrated tips. Avicular uncini from setiger 2, arranged in single rows for first 6 uncinigerous segments, following ones in double rows. Abdominal uncini in single rows on small sessile pinnules. Prominent nephridial papillae on segments 3-5.

REMARKS: The specimens from Peel Island have 22-24 thoracic setigers. Fauvel (1917) describes 23 setigers for *A. rubra* but synonymises it with *A. chloraema* (Schmarda), which is described as having 22-25 setigers; later Fauvel (1927), gives a range of 22-24 setigers for *A. rubra* so that the Peel Island specimens fall within this range.

Knox and Cameron (1971) reported *A. rubra* from Port Phillip Bay, Victoria. On re-examining this material, only 1 specimen from Area 16, St. 142 (NMV G.1819) was found to be *A. rubra;* the rest of the material is a new genus close to *Pista,* which is currently being described. Another record of *A. rubra* from this locality has been obtained during the subsequent Port Phillip Bay Environmental Study 1969-1971. (Poore, Rainer and Spies, 1975). All the material of Rullier (1965) has been re-examined, and agrees with his diagnosis except that lot G.3918 is dehydrated, and cannot be positively identified.

DISTRIBUTION: Australia; Mediterranean; Red Sea; Japan; New Zealand; Chile.

Hadrachaeta n.g.

DIAGNOSIS: Compact prostomium with thickened outfolded lips, numerous thick grooved oral tentacles. Three pairs of simple gills on segments 2-4. Lateral lobes poorly defined. Notopodia from segment 4 (3rd branchiferous) and continue for 16 segments, with finely serrated capillary notosetae. Uncini from setiger 2, and continue to pygidium. Uncini of 1st, 4 rows, heavily chitinized long handled hooks, following ones avicular.

Type species **Hadrachaeta aspeta** n.sp., by present designation

Hadrachaeta aspeta n.g., n.sp.

Fig. 8 a-d

MATERIAL EXAMINED: New South Wales — Patonga Creek, Broken Bay, W. McCormick, coll., in mud adjacent to seaward margins of mangroves, *Avicennia marina* (Forsk.), Jan. 1973 — holotype and paratype (AM W. 6801/6854); paratype (USNM 52623); 6 paratypes (BMNH, ZB. 1975-133-138). Yamba, W. McCormick, coll., in mud in front of mangroves, March 1973 — 12 paratypes (AM W. 6855/6). Queensland — Moreton Bay, Queensland Museum Party, coll., Serpentine Creek, 3.4 km upstream, transect 3L site V, muddy bank, Aug. 1972 — paratype (QM G. 8165). Brisbane River, C. Wallace coll., from mangroves, transect 3L, site U — paratype (AM W. 6853).

Size — holotype (complete) 25 mm long, 4 mm wide at anterior end. Paratypes (QM G. 8165, USNM 52623) 15 mm long, 2-3 mm wide anteriorly.

DESCRIPTION: Compact prostomium with thickened outfolded lips. Numerous thick,grooved oral tentacles (fig. 8a). Eye spots absent. Three pairs of gills, segments 2-4, each gill consisting of numerous simple unbranched gill filaments borne on a short broad stalk. Lateral lobes poorly defined, present only as slightly raised margins on segments 4 and 5. Notopodia present from segment 4 (3rd branchiferous), continue for next 16 segments. Notosetae arranged in 2 distinct tiers with about 8 large setae in dorsal tier and about 10 shorter ones in ventral tier. Notosetae wing-less capillaries, tips slightly flared and distinctly serrated, tapering to a fine point (fig. 8b). Uncini begin on setiger 2 and continue to pygidium. Length of first 4 rows of uncini slightly shorter than following thoracic rows. Uncini of first 4 rows, heavily chitinized long handled hooks (fig. 8c). Following neurosetae typical avicular uncini with 2 rows of teeth above main fang (MF: 5-7:8), arranged in double rows from setiger 11. In posterior thoracic segments, dorso-lateral portion of uncinial row deflected posteriorly. Abdominal uncini borne on sessile pinnules, the rows and size of uncini become shorter and smaller towards pygidium. First 9 setigerous segments with well marked ventral pads, and tissue surrounding rows of uncini glandular; tissue gradually becoming less glandular posteriorly. Holotype, mature with large yolky eggs. Nephridial papillae on setigers 6-10.

REMARKS: *Hadrachaeta aspeta* is placed in the family Terebellidae, subfamily Amphitritinae, as it has serrated notosetae, distinct ventral pads, compact prostomium, the majority of uncini avicular and generally resembles other members of this subfamily. The first 4 rows of uncini are simple long handled hooks which could be compared to the anterior uncini of *Pista* which have elongated shafts, although they lack the crested head characteristic of *Pista*. These simple hooks do not resemble the thoracic long handled, heavily crested hooks found in the Trichobranchidae. *Hadrachaeta* also shares some characteristics with *Amphitrite* and *Terebella*, in having serrated tipped notosetae, and some species of *Amphitrite* also have simple unbranched gills.

Lanice Malmgren, 1866

DIAGNOSIS: Compact tentacular lobe, with numerous long oral tentacles and eye spots. Branched gills on segments 2-4. Lateral lobes on segments 1-3. Notosetae start on segment 4, continue for 17 segments, smooth tipped winged capillary setae. Avicular uncini from segment 5, arranged back to back on posterior thorax, in double rows.

Lanice conchilega (Pallas, 1766)

Lanice conchilega. — Hessle, 1917: 168-169. — Fauvel, 1927: 255-257, fig. 88 a-h. — Day, 1967: 743-744, fig. 36. 8 n-r. — Knox and Cameron, 1971: 38.

MATERIAL EXAMINED: Queensland — Moreton Bay, Stephenson, et al., coll., south of Peel Island, St. II A4/D5, III C2, June/Sept. 1970, 5-8 m (AM). Victoria — Port Phillip Bay Environmental Study, 1957-1963, (NMV G. 1731) (Knox and Cameron, determined, 1971).

DESCRIPTION: Segment 1 with very large ventro-lateral lobes, continuous ventrally forming a sheath for oral tentacles. Lateral lobes absent on segment 2, segment 3 with large square lobes. Three pairs of equal sized branched gills, with short trunks on segments 2-4. Fourteen to 20 ventral pads fused together, tapering to a glandular streak on posterior thorax. Nephridial papillae on segments 3 and 6-9. Avicular uncini with main fang and 2 rows of teeth above, with 2 and 3-6 teeth respectively (MF: 2:3-6). No tubes retained with Moreton Bay material, Victorian material had tubes made of sand and shell fragments.

DISTRIBUTION: Australia; Japan; Iranian Gulf; south and west Africa; Atlantic from Sweden to English Channel; Mediterranean; S. California.

Loimia Malmgren, 1866

DIAGNOSIS: Tentacular lobe short and compact, with eye spots. Lateral lobes present on anterior segments. Branched gills on segments 2-4. Notosetae start on segment 4, continue for 17 segments, smooth tipped capillary setae. Pectinate uncini from segment 5, arranged in double rows on posterior thorax. Ventral pads present.

KEY TO SPECIES RECORDED FROM AUSTRALIA

1. Uncini with 4-5 teeth in a vertical row ..... *L. ingens*
— Uncini with 6-7 teeth in a vertical row ..... *L. medusa*

Loimia ingens (Grube, 1878)

Terebella ingens Grube, 1878: 228-230, pl. 13, fig. 1.
Loimia ingens. — Hessle, 1917: 170.
Loimia nr. ingens. — Hartman, 1966: 364, pl. 38.

MATERIAL EXAMINED: Queensland — Moreton Bay, Stephenson, et al., coll., south of Peel Island, St II B3, Sept. 1971, 7 m (AM); Port Douglas, McCulloch, coll., St. Crispin Reef, outer edge, 1918 (AM W. 7990). New South Wales — Long Reef, Collaroy, Bennett, coll., Oct. 1963 (AM W. 3803), (Hartman, determined, 1966). New Hebrides — Malekula, South West Bay (AM W. 2798).

DESCRIPTION: Tentacular lobe short and compact, with oral tentacles transversely banded with discrete spots of pigment. Well developed lateral lobes on segments 1 and 3. Notosetae, 17 pairs of smooth tipped capillary setae. Pectinate uncini usually with 4 teeth plus rudimentary 5th tooth in a vertical series. Occasionally, 5th tooth well developed in thoracic uncini. Abdominal uncini often only with 4 teeth, (considerable variation in dentition of uncini within individual). All uncini with well developed spur. Uncini in double rows from 8th setiger.

REMARKS: Hartman (1966) recorded *Loimia nr. ingens* from Long Reef, Collaroy, Sydney, New South Wales and was doubtful of the species because the number of uncinial teeth varied between 3-5. There is also some confusion in the literature, as Grube in the original description states 3 teeth but figures 4. All the specimens examined have two well developed lateral lobes on segments 2 and 3 which distinguishes it from *L. medusa*, which is also present in Moreton Bay. At this stage these 2 specimens from Moreton Bay are referred to *L. ingens*.

DISTRIBUTION: Australia; Philippines.

Loimia medusa (Savigny, 1818)

Loimia medusa. — Augener, 1922: 46-48; 1927: 253-254. — Rullier, 1965: 195-196. — Day, 1967: 743, fig. 36. 9 a-e.
Loimia montagui. — Augener, 1926: 465-466. — Monro, 1931: 29.

MATERIAL EXAMINED: Queensland — Moreton Bay, Stephenson, et al., coll., south of Peel Island, St. IC4/D4 June 1970/1971, 4 m, St. II A5/B1 March/Sept. 1971, 6-7 m, St. III A4/B2/B3/D2/D4/D5/E2/E3/E4 June/Dec. 1970, June/Sept. 1971, 2-6 m; Middle Banks off Tangalooma, St. 33/42/44/46/48/49/52/56/57 June 1970 (AM). Dredged SE of Peel Island, Nov. 1961, south end of Moreton Island, April 1961, 34 m, Redland Bay, April 1961. Hailstone and party, coll., Rainbow Channel, June 1962. (QM G. 3916, 3925, 3927, 3954), (Rullier, determined, 1966).

DESCRIPTION: Tentacular lobe short, with oral tentacles banded with purple. Three pairs of similarly sized branched gills. Buccal segment with large membranous lower lip. Segments 2 and 3 with large fused lateral lobes. Pectinate uncini with 6-7 teeth in a vertical row (variation within an individual), 7th tooth not always rudimentary. Double rows of uncini from setiger 8. Discrete ventral pads extend to setiger 9 or 10. Nephridial papillae present on segments 6-8.
REMARKS: Day (1967) commonly found that the 1st pair of gills was the largest, whereas the specimens from Moreton Bay had equal sized gills.

DISTRIBUTION: Australia; Solomon Islands; India; Red Sea; S. Africa; English Channel; N. Carolina and California, U.S.A.; Japan.

Pista Malmgren, 1866

DIAGNOSIS: Compact tentacular lobe, numerous oral tentacles. Lateral lobes on segments 2-4. One to three pairs of gills. Notosetae from segment 4, continue for 17 pairs, smooth tipped capillaries. Uncini start on segment 5, uncini on anterior thoracic segments with posteriorly elongated bases, following uncini avicular, arranged in double rows.

KEY TO SPECIES RECORDED FROM AUSTRALIA

1. Gills, 2 pairs 2
— Gills, 3 pairs 3

2.(1) Gills tufted ..... *P. trunca* n. sp.
— Gills club-shaped ..... *P. typha*

3.(1) Gills short tufted ..... *P. trina* n. sp.
— Gills with short branches along one side of main stem .. *P. pectinata* n. sp.

Pista pectinata n.sp.
Fig. 9 a-g

Pista sp. 1 Stephenson, et al., 1974: 113.

MATERIAL EXAMINED: Queensland — Moreton Bay, Stephenson, et al., coll., south of Peel Island, St. I B5, Dec. 1971, 5 m, St. II A1/B2/C5/D5 March/June/Dec. 1970, June/Dec. 1971, 6-8 m — holotype (AM W. 6795), paratypes (QM G. 8163), (BMNH. ZB.H. 1975 — 139), (USNM 52622), (AM W. 6796,6797).

Size — holotype (incomplete posteriorly) 55 mm long, 71 segments, 50 of them abdominal. Paratype (QM G. 8163) (incomplete posteriorly) 10 mm long; paratype (BMNH, ZB. 1975-139) (incomplete posteriorly, some gills absent) 8 mm long, 27 segments; paratype (USNM 52622) (incomplete posteriorly, 1 gill of 1st pair absent) 15 mm long, 28 segments.

DESCRIPTION: Tentacular lobe thick and convoluted, pigmented brown. Eye spots absent. Three pairs of gills on segments 2-4, 1st pair extend back to setiger 10, 2nd pair to setiger 8 and 3rd pair to setiger 3. Gills have long main stems, with short branches of approximately same length, coming off along one ridge of stem (fig. 9 a), side branches divided. Lateral lobes present on branchial segments 2-4. First pair on segment 2, large and semicircular, fused midventrally forming ventral collar, not extending as far dorsally as following pair. Second pair separate and rectangular, overlapping base of first pair. Third pair smaller and ovoid. Seventeen pairs of notopodia with smooth tipped narrow winged capillary setae from segment 4 (third branchiferous segment) (fig. 9 b). Uncini begin on setiger 2 and present on all remaining abdominal segments. Rows of thoracic uncinigerous tori surrounded by distinctive glandular tissue. Thoracic uncini arranged in double rows from 8th setiger; with similarly developed, short, blunt, moderately well chitinized shafts (fig. 9c-f), and crested head with at least 3 rows of teeth above main fang, (MF: 5: 5: 3-2), and with fibrous tuft on mid-basal surface. Short rows of abdominal uncini borne on rectangular elevated tori. Abdominal uncini much smaller than thoracic ones, the shaft is virtually absent with 5 secondary teeth above main fang and at least 2 rows of numerous smaller teeth above secondary teeth (fig. 9g). Well developed glandular ventral pads present. Lives in fairly rigid sandy mud tube, with shell fragments embedded in walls.

REMARKS: *Pista* is a large genus with over 40 described species, although some of the descriptions are inadequate. (The generic description given at the beginning of this section is based upon Hessle (1917), description of the type species *P. cristata*.) The genus is in need of revision, which is in in preparation. Useful specific characters are the number and type of gills, the shape of the lateral lobes and the thoracic uncini, especially those of the first few rows. Six previously described species of *Pista* have 3 pairs of gills; *P. cretacea* (Grube); *P elongata* Moore; *P. foliigeraformis* Annenkova; *P. pacifica* Berkeley and Berkeley; and *P indica* Fauvel. The last species should probably be removed from this genus as it has serrated notosetae. The gills of all these species do not in any way resemble the distinctive gills of *Pista pectinata*. Another distinguishing feature is the presence of moderately well developed shafts on all thoracic uncini, in *P. pectinata*, in contrast to many species where the shaft is restricted to the anterior uncinigerous segments. Four other species of *Pista* have shafts on all thoracic uncinigerous segments; *P. brevibranchia crassa* Caullery; *P. fasciata* (Grube); *P intermedia* Webster and Benedict; and *P. microlobata* Hessle; these species have 2 pairs of gills, with different arrangement of gill branches. These two distinctive features, together with the presence of large lateral lobes, the 1st pair being fused midventrally, characterize *P. pectinata*.

Pista trunca n.sp.
Fig. 10 a-f

Pista sp. 2 Stephenson, et al., 1974: 113.

MATERIAL EXAMINED: Queensland — Moreton Bay, Stephenson, et al., coll., south of Peel Island, St. II B5/C2/E3 Sept./Dec. 1970, Dec. 1971, 7-8 m — holotype (AM W.6973), paratype (QM G.8162) (AM W.6794).

Size — holotype 35 mm long, paratype (QM G. 8162) 28 mm long, with 1 gill, paratype, (AM W. 6794), specimen with no gills.

DESCRIPTION: Tentacular lobe with thickened trumpet shaped lips, and a few thick, strongly grooved tentacles. Eye spots absent. Two pairs of dichotomously branched gills with short thick stalks on segments 2 and 3, first pair the largest (fig. 10a). Buccal segment with a pair of large semicircular lobes meeting midventrally at distinct notch, encompassing tentacles. Lateral lobes on segments 2-4; laterally thickened with narrow ridges, expanding ventrally, meeting midventrally in depression on segment 2; large semicircular, slightly fluted and ridged, extending dorsally to notopodia and ventrally to margins of ventral pads on segment 3; narrow, rectangular with interconnecting raised strip across dorsum on segment 4. Seventeen pairs of notopodia with smooth tipped winged capillary notosetae, beginning on segment 4 (fig. 10b). Uncini begin on setiger 2, arranged in double rows from setiger 8. All thoracic uncini have poorly chitinized shafts, although those on posterior thorax not as well developed (fig. 10c-e). Thoracic uncini have 3 rows of teeth above main fang (MF:3:6:10). Abdominal uncini on prominent projecting pinnules, also with 3 rows of teeth above main fang (MF:3:6:8-10), lacking shafts (fig. 10f). Anterior ventral pads poorly developed, posteriorly restricted to narrow slightly elevated midventral streak. Posterior margin of ventral pad wider than anterior margin.

REMARKS: Four described species of *Pista* have 2 pairs of gills and thoracic uncini with shafts: *P. brevibranchia crassa* Caullery; *P. fasciata* (Grube); *P. intermedia* Webster and Benedict; and *P. macrolobata* Hessle. *P. trunca can be distinguished from P. brevibranchia crassa* and *P. intermedia* by the arrangement of the gills, arranged in whorls in the former and in a slow ascending spiral in the latter. *P. trunca* has similar gills to *P. macrolobata* and *P. fasciata* but can be distinguished by the arrangement of the lateral lobes and thoracic uncini. *P. macrolobata* has very weakly developed shafts on thoracic uncini, although the figures of Hessle (1917: fig. 36c) and Fauvel (1932: fig. 39a) do not agree, even though Fauvel states that his specimens agree with those of Hessle. *P. macrolobata* also differs in the arrangement of the lateral lobes; they are absent on segments 2 and 4; *P. fasciata* lacks lateral lobes on segment 4, and the thoracic uncini lack well developed shafts. However, the dental formulae of the uncini of *P. fasciata* (MF: 4: 7ca 12, Day, 1967) and *P. trunca* are similar.

Pista trina n.sp.
Fig. 11a-e

Pista sp. 3 Stephenson, et al., 1974: 113.

MATERIAL EXAMINED: Queensland — Moreton Bay, Stephenson et al., coll., south of Peel Island, St. IIE, Sept. 1971, 8 m; Middle Banks off Tangalooma, St. 22 Sept. 1969 — holotype (AM W. 6798), paratype (QM G. 8164).

Sizes — holotype (AM W.6798) 145 mm long, 11 mm wide across thorax. Paratype (QM G.8164) (incomplete posteriorly) 50 mm long, 10 mm wide across thorax, 38 segments, 17 of them abdominal.

DESCRIPTION: Compact tentacular lobe, buccal segment with small, thickened, trumpet shaped lower lip with fluted edges. Eye spots absent. Three pairs of dichotomously branched gills on short stout stalks, on segments 2-4. Thick branches arise from main stem, each branch with short, compact feathery appendages. First pair of gills slightly larger (fig.11a). Lateral lobes on segments 2 and 3. Both pairs of lateral lobes arising at acute angle of 60° to body surface and pointing towards tentacles. Lobes of segment 2, semicircular extending from midlateral body wall to midventrum, but not fusing; segment 3, large, pinnate lobes extending from ventral pads to notosetae. Seventeen pairs of notopodia with smooth tipped winged capillary notosetae of 2 lengths, present from segment 4 (3rd branchiferous) (fig.11b). Uncini begin on setiger 2, arranged in double rows from uncinigerous segment 7. Uncini of anterior thoracic segments have long chitinized shafts; by uncinigerous segment 6, shafts are small and tapered (fig.11c-d). In posterior thoracic

segments, shafts reduced to a tapering ligament. Uncini arranged in short rows up to uncinigerous segment 6, then gradually increase in length until the 15th, they almost extend to midventrum. Thoracic uncini have 3 rows of teeth above main fang (MF: 1:2-3:5). Abdominal uncini, smaller, borne on raised, rectangular pinnules, with 3 rows of teeth above main fang (MF: 2:3:4) (fig.11e). Ventral pads of first 6 segments, fused forming a single slightly raised corrugated pad; following ones much narrower, restricted to ventral groove, continuing on abdomen. Single nephridial papilla clearly visible on one side of segment 5 between noto and neuropodia on holotype. Gonopores not visible and mature gametes absent. Lives in firm substantial tube several mm's thick, composed of sand and shell fragments.

REMARKS: *Pista trina* is closest to *P. cretacea* (Grube), described from the Mediterranean, but it differs in the following points. *P. cretacea* has a prolonged cephalic lobe with an upper elevated lip and the buccal segment forming a lower lip, both of which are poorly developed in *P. trina*. Fauvel (1927) reported that the lateral lobes on segment 2 are triangular and located just below the mouth in *P. cretacea* whereas these lobes are semicircular and ventrolateral in position in *P. trina*. The arrangement of the ventral pads also differs. Finally, *P. cretacea* has uncini with elongated shafts on only the first 3 thoracic uncinigerous segments in contrast to *P. trina*, where shafts, though considerably reduced, are still present on uncini from the 6th uncinigerous segment. *P. trina* differs from other described species which have 3 pairs of gills, in the structure of the gills and thoracic uncini (for a discussion of these species, see under remarks, *P. pectinata*).

Pista typha Grube, 1878
Fig. 12a-b

Pista typha. — Hessle, 1917: 155. — Augener, 1927: 254-257, fig. 17. — Monro, 1931: 30, fig. 15a-c. — Knox and Cameron, 1971: 38. — Stephenson, et al., 1974: 113.

MATERIAL EXAMINED: Queensland — Moreton Bay, Stephenson, et al., coll., south of Peel Island, St II A4/C4/C5/D4/D5, 6-8 m, St. III A2/E1/E3/E5, June 1970/June/Sept./Dec. 1971, 4-6 m (AM). Victoria — Port Phillip Bay Environmental Study, 1969-1971, Area 28(286) (NMV G.1717) (Knox and Cameron, determined, 1971).

DESCRIPTION: Compact prostomium. Eye spots absent. Two pairs of long stalked club-shaped gills with branches coming off main axis in tiers, on segments 2-3. First pair of gills much larger than 2nd pair. Large semicircular lateral lobes on segments 2 and 3, and very small lobes on segment 4. First and 2nd segment twice width of 3rd. Notopodia from segment 4, continuing for 17 segments, notosetae winged capillaries with smooth tips. Uncini from segment 5, arranged in single rows for first 6 uncinigerous segments, following thoracic uncinigerous segments have double rows. Uncini of 1st uncinigerous segment with long fairly heavily chitinized shafts (fig. 12a), this shaft gradually reduced, by 6th uncinigerous segment absent (fig. 12b). Abdominal uncini avicular, arranged on small pinnules. All uncini have strongly crested heads, with 4 rows of teeth above main fang (MF: 4:5:6:6). Twenty well delineated ventral pads tapering off to a distinct glandular groove continuing onto abdomen. Nephridia present on setigerous segments 6 and 7, with very long tubercles.

REMARKS: Hessle (1917), in his description of *P. typha* does not indicate which thoracic uncini have shafts. Fauvel (1953), figures an uncini from the 6th uncinigerous segment (setiger 7) indicating that at least the first 6 rows of uncini have shafts. However, the specimens examined from Port Phillip and Moreton Bay had virtually lost the shaft by the 6th uncinigerous segment.

Pista typha has been recorded from Low Isles, Great Barrier Reef by Monro (1931), although he states that he found it difficult to distinguish *P. typha* from the widely distributed *P. cristata*. Material of *Pista cristata* from near the type locality (Herdla, Hordaland, Norway in 90-95 m, ZMB, AM) was examined and agrees with the description given by Hessle. His description can be expanded however, to include the fact that the dendritic branches of the gills are spirally distributed around the main axis. The specimens from Norway also differ from *P. typha* in the shape of the lateral lobes and by having uncini with much stronger chitinized shafts (fig. 12c-e). The shaft is still obvious on the 5th uncinigerous segment, but by the last thoracic segment is barely visible. The uncini have 4 to 5 rows of teeth above the main fang (MF: 5:5:5:6). So that the 2 closely related species *P. typha* and *P. cristata* can be differentiated by the arrangement of the gill branches and the degree of chitinization of the shaft of the anterior thoracic uncini.

Pista typha is also closely related to *P. brevibranchia* Caullery and *P. brevibranchia crassa* Caullery, and it is likely that *P. brevibranchia* could be synonymised with *P. typha*, as the arrangement of the gills is similar. The shaft and the margins of the uncini from the anterior segments of *P. brevibranchia* are well chitinized, and the shaft diminishes on uncini of more posterior segments, again similar to *P. typha*. *P. brevibranchia crassa* however, differs from the other two species as the shaft of the uncini of anterior segments is hardly chitinized. Caullery also erected *P. typha aequibranchia* which he distinguished from the stem species, by having both pairs of gills almost equal in size, these gills are unequal in size in *P. typha*. The sub-species also has weakly developed shafts on the uncini of the anterior segments, which suggests that this sub-species should be considered a species in its own right. These problems cannot be resolved until Caullery's material is re-examined.

DISTRIBUTION: Australia; Solomon Islands; Indo-West Pacific; Philippines; India; Japan; Indonesia.

Family **Trichobranchidae** Malmgren, 1866

List of species reported from Australia

Artacamella dibranchiata Knox and Cameron, 1971. Port Phillip Bay, Victoria. Referred to Trichobranchidae. See below.

Terebellides stroemii Sars, 1835. Westernport; Port Phillip Bay, Victoria (Knox and Cameron, 1971); Sydney, New South Wales (Augener, 1927); Moreton Bay (Rullier, 1965; Stephenson, et al., 1974).

Terebellides sp. Cockburn and Warbro Sound, Western Australia (Augener, 1914).

Trichobranchus glacialis Malmgren, 1866. Moreton Bay, Queensland (Stephenson, et al., 1974). Referred to *Artacamella dibranchiata*. See below

KEY TO THE GENERA OF TRICHOBRANCHIDAE FROM AUSTRALIA

1. Single branchial trunk distally divided into 4 lamellate lobes . . *Terebellides*
   Gills, simple filaments ..... *Artacamella*

Artacamella Hartman, 1955

DIAGNOSIS: Prostomium inconspicuous lobe, ventral part of peristomium, forms conspicuous ridged proboscis. Upper part of peristomium forms a three-lobed membrane, with tentacles. Simple unbranched gills, 2-3 pairs on segments 1-3. Notopodia from segment 5, 15 pairs with smooth tipped notosetae. Uncini from segments 4 or 5, continuing for many segments. Thoracic uncini long handled hooks, abdominal ones avicular.

Artacamella dibranchiata Knox and Cameron, 1971.
Fig. 13a-c

Artacamella dibranchiata Knox and Cameron, 1971: 36-38, figs. 32-35.
Trichobranchus glacialis. — Stephenson, et al., 1974: 113. Not Malmgren, 1866.

MATERIAL EXAMINED: Victoria — Port Phillip Bay — holotype and paratype (NMV G.1758/9). Port Phillip Bay Environmental Study 1969-1971, St. 931/962, sand and clay, 15-24 m (FWV 1661). Queensland — Moreton Bay, Stephenson, et al., coll., south of Peel Island, St. II E2 Dec. 1971, 8 m (AM).

DESCRIPTION: Prostomium compact, peristomium small, strongly ridged longitudinally to form proboscis. Proboscis divided into 2 parts; strongly ridged triangular superior cone, with base curved ventrally; smaller less strongly ridged glandular fold arising inferiorly from base. Tripartite frilly dorsal membrane completely encompassing expanded upper lip. Margins of upper lip covered with short thin tentacles. Transverse line of pigment spots occur at dorsal base of tentacles. Two pairs of simple, unequal gill filaments on segments 1-2. Segments 1 and 2 with thickened anterior margins, perhaps lateral lobes. Segment 3 achaetous. Uncini present from segment 4, occasionally 5, and on all abdominal segments present (ca 35), in single rows throughout. Thoracic uncini long handled hooks with 1 row of secondary teeth above main fang (MF: 3-4). Abdominal uncini, avicular with fluted edge, and crested head, above main fang (fig. 13b-c), on small projecting pinnules. Notopodia begin segment 5, continue for 15 segments, notosetae simple smooth tipped winged capillaries, variable in length, arising from prominent setal sacs. Ventral pads absent, individual segments glandular. Nephridial papillae or nephridiopores not visible, even though some specimens mature with gametes.

REMARKS: Knox and Cameron (1971) reported that thoracic uncini and notosetae begin on the same segment, but most of the specimens examined (10) including the types from Port Phillip Bay, had thoracic uncini beginning on segment 4 and notosetae from segment 5; the other 2 specimens differed, one had uncini and notosetae both beginning on segment 5, and the other had uncini beginning on segment 4 on one side and segment 5 on the other. These 2 specimens did not differ in any other way from the type material. The single specimen from Moreton Bay had uncini and notosetae both beginning on segment 5, indicating the variability found in this species with respect to where the uncini begin. Knox and Cameron reported that the abdominal uncini were long handled hooks like the thoracic ones, whereas they are avicular.

The genus *Artacamella* was erected by Hartman (1955) for *A. hancocki* and placed with *Artacama* Malmgren, in the subfamily Artacaminae (F. Terebellidae) as the ventral part of the peristomium is modified to form a conspicuous proboscis. However, *Artacama* has avicular uncini, resembling those of other terebellids, whereas *Artacamella* has thoracic uncini which are long handled hooks. The only terebellid with some thoracic uncini modified as long handled hooks is *Hadrachaeta aspeta* Hutchings, but these hooks have only 1 row of secondary teeth above the main fang, whereas those of *Artacamella* have strongly crested hooks. Thoracic uncini resembling those of *Artacamella* are found among all members of the family Trichobranchidae, except for *Filibranchus* Malmgren, for which it is not known. Other similarities between *Artacamella* and the 7 described genera of trichobranchids exist, such as the presence of simple gill filaments in 4 genera. Also most of them have some expansion of the peristomium, e.g. *Novobranchus* Berkeley and Berkeley, *Terebellides* Sars and *Unobranchus* Hartman, and in the other genera some expansion may be present but there is considerable confusion in the literature regarding the terminology of the anterior structures. For all these reasons *Artacamella* is removed from the Terebellidae and put into the Trichobranchidae. Within the trichobranchids, *Artacamella* is closely related to *Trichobranchus*, but they differ in the possession of a compact proboscis and expanded tentacular lobes respectively.

Terebellides Sars, 1835

DIAGNOSIS: Tentacular lobe large, deeply grooved, peristomium modified as prominent lower lip. Single gill on a stout trunk bearing 4 lamellate lobes. Winged capillary notosetae from segment 3, 18 pairs neurosetae from setiger 6, thoracic uncini long shafted hooks, abdominal uncini avicular.

Terebellides stroemii Sars, 1835

Terebellides stroemii. — Hessle, 1917: 137-138. — Augener, 1927: 258. — Fauvel, 1927: 291-292, fig. 100i-q. — Rullier, 1965: 197. — Stephenson, et al., 1970: 491. — Knox and Cameron, 1971: 34. — Stephenson, et al., 1974: 87, 102, 113.

MATERIAL EXAMINED: Queensland — Moreton Bay, Stephenson, et al., coll., south of Peel Island, St. I A1/A3/A4/A5/B3/B4/C5/E1, 4-6 m, St. II A2/C1/D2/D3, 6-8 m, St. III C1/C2, 5 m, June 1970/June/Sept. 1971; Middle Banks off Tangalooma, St. 28/31/33/34/35/40/41/49/51/52/53/56/57, Sept./Dec. 1972 (AM), (QM). Victoria — Port Phillip Bay, Area 37 (48), (NMV) (Knox and Cameron, determined, 1971).

DESCRIPTION: Tentacular lobe expanded with numerous short oral tentacles. Prominent lower lip. Eye spots absent. Single gill arises from segments 2-4, with stout trunk bearing 4 partially fused lamellate lobes, outer pair larger than inner one. Notopodia with smooth tipped capillaries from segment 3, continue for 18 segments. Uncini begin on setiger 5 or 6, according to size; specimens 8-21 mm, uncini from setiger 5, and from setiger 6 on larger specimens. First row of uncini, stout unidentate slightly bent acicular setae, subsequent thoracic uncini, thinner long handled hooks with crested heads. Abdominal uncini avicular, on projecting pinnules; about 30 uncinigerous abdominal segments. Prominent glandular folds on setigers 1-5.

REMARKS: Rainer (pers. comm.) has found similar variations with size, and the segment on which the uncini begin, in the population from Port Phillip Bay.

Within the Moreton Bay populations, a considerable range of sizes was found, one of the smallest complete individuals was 10 mm long and full of oocytes, and another incomplete individual was 32 mm long, with 16 setigers, suggesting that the worms breed several times during their life.

DISTRIBUTION: Cosmopolitan.

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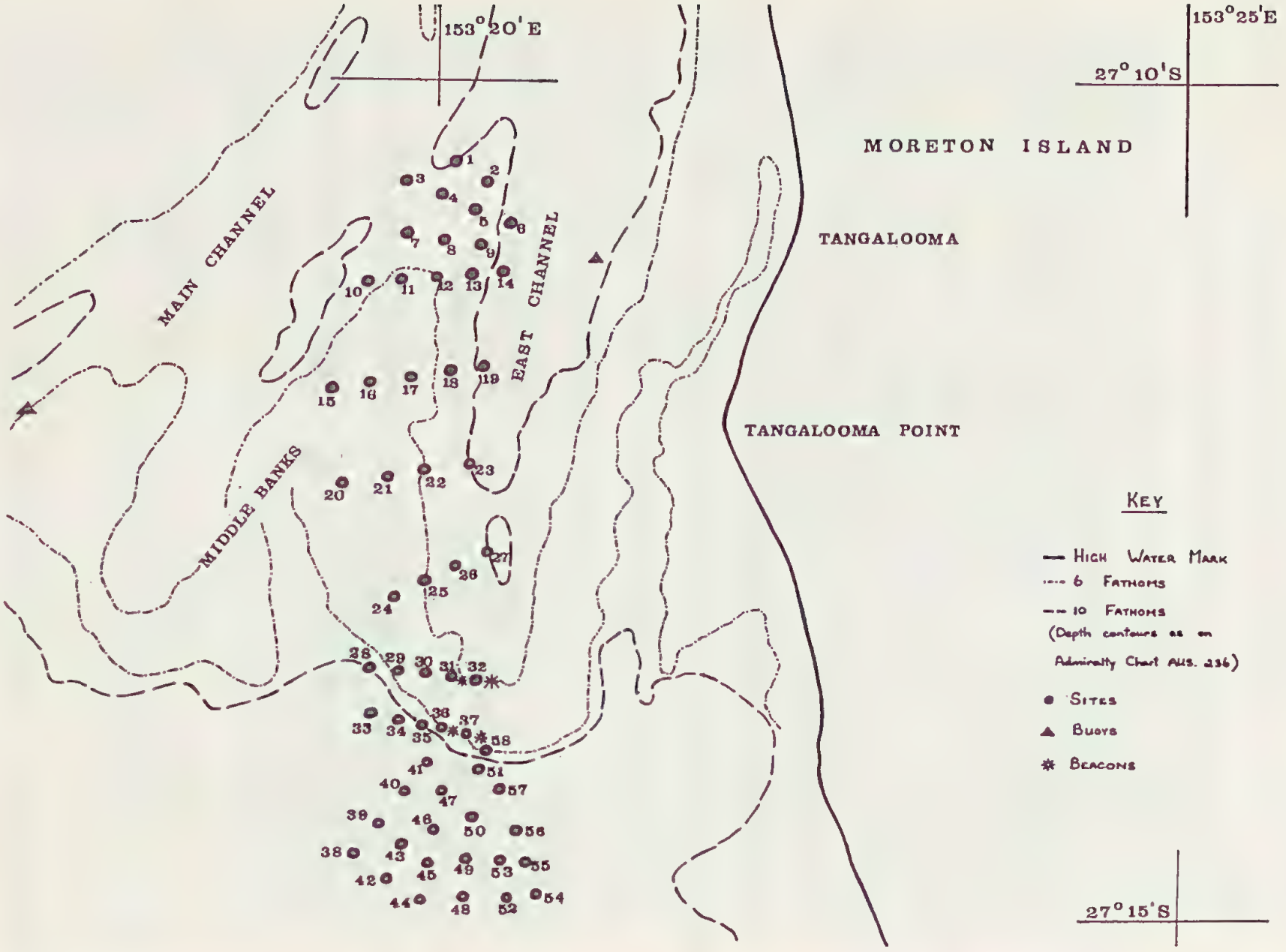


Fig. 1. Map of Middle Banks off Tangalooma, Moreton Bay, showing location of sampling sites.

Fig. 2. *Auchenoplax mesos* n.sp. a. Ventrolateral view of anterior end. b. Posterior thoracic notopodium. c. Face on view of thoracic uncinus.

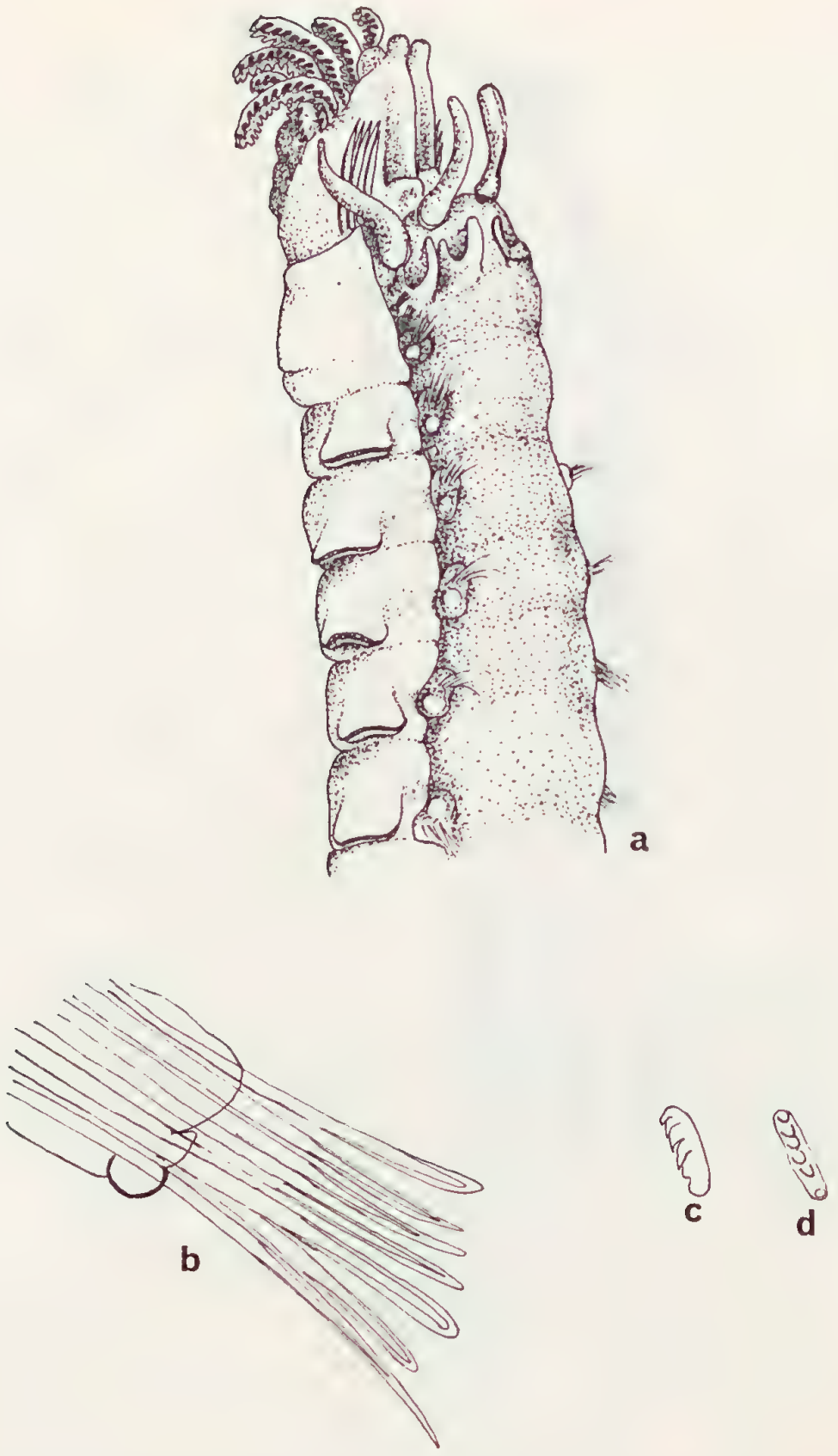


Fig. 3. *Pseudoamphicteis papillosa* n.g., n.sp. a. Dorsolateral view of anterior end. b. Thoracic notopodium. c,d. Views of thoracic uncinus. e. Abdominal nuropodia and notopodial cirrus.

Fig. 4. *Litancyra octoseta* n.g., n.sp. a. Ventrolateral view of anterior end. b. Thoracic notopodium. c. Tip of thoracic notoseta. d. Abdominal uncinus.

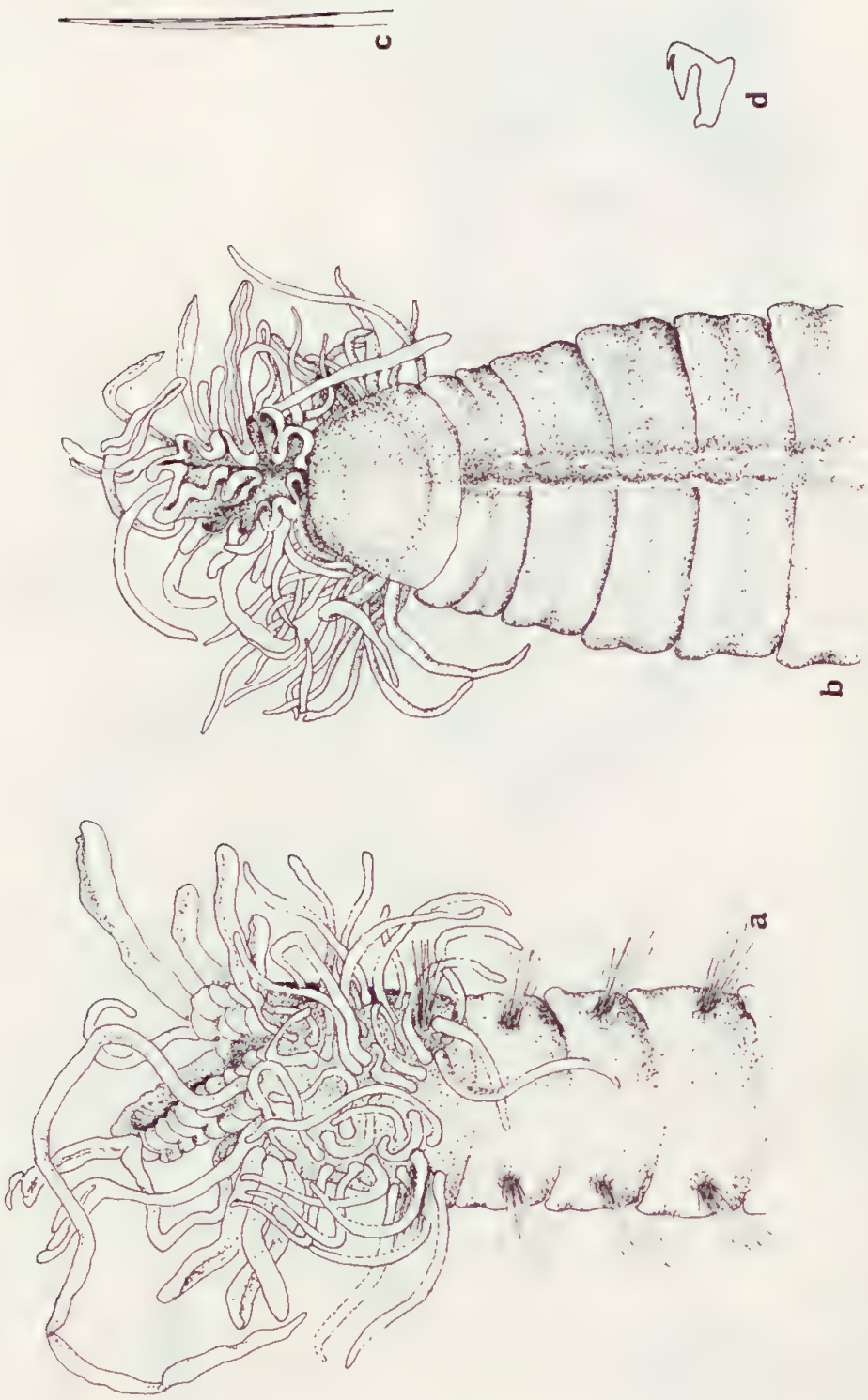


Fig. 5. *Decathelepus ocellatus* n.g., n.sp. a. Dorsal view of anterior end. b. Ventral view of anterior end. c. Thoracic notoseta. d. Thoracic uncinus.

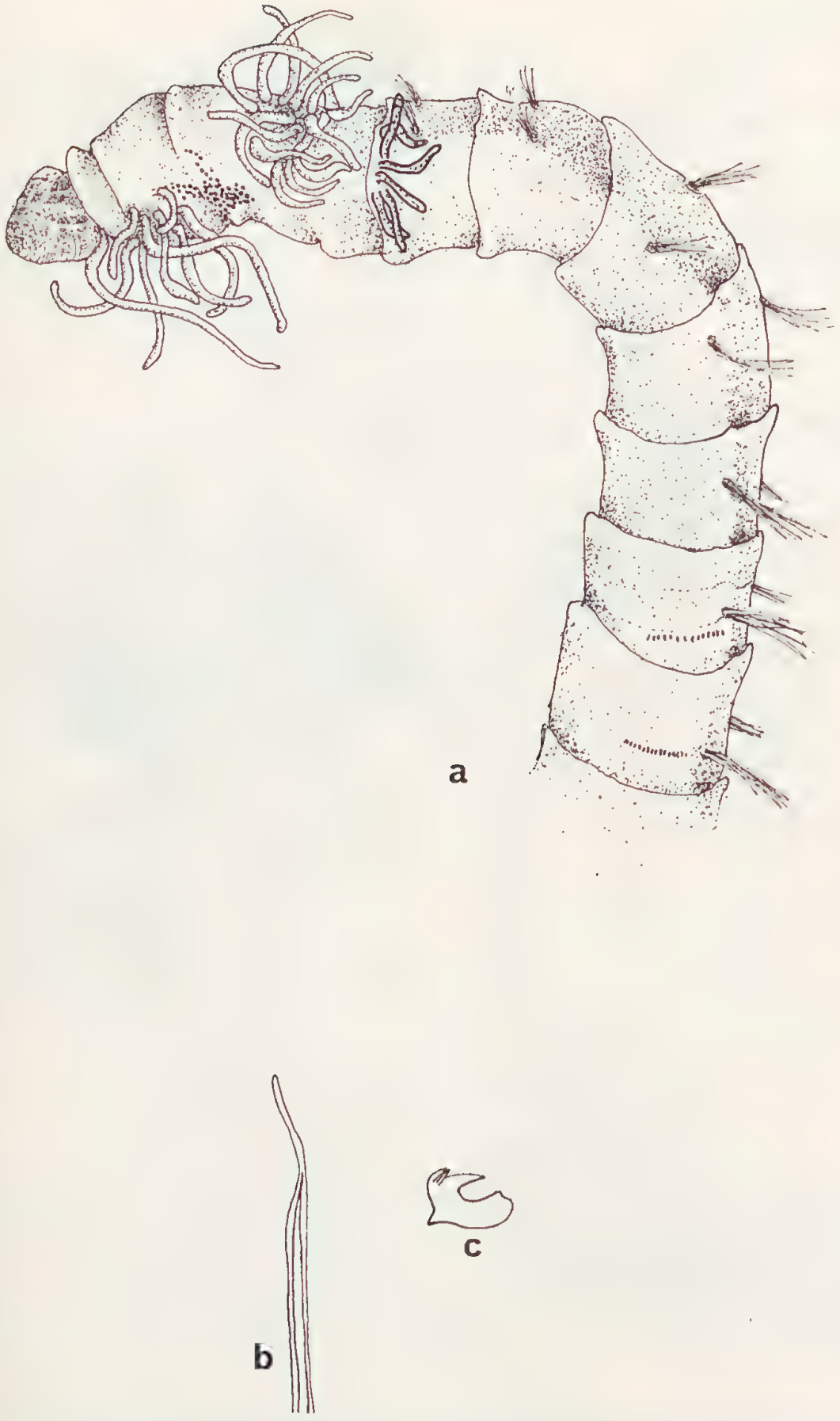
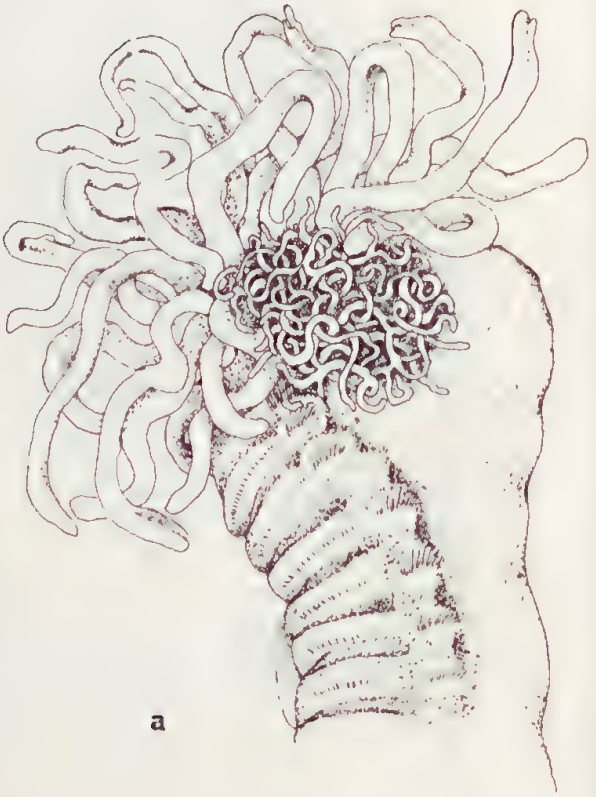


Fig. 6. *Rhinothelepus macer* n.sp. a. Dorsolateral view of anterior and. b. Thoracic notoseta. c. Thoracic uncinus.

a

b

Fig. 7. *Thelepus plagiostoma* a. Lateral view of thoracic uncinus. *Thelepus robustus.* b. Lateral view of thoracic uncinus.



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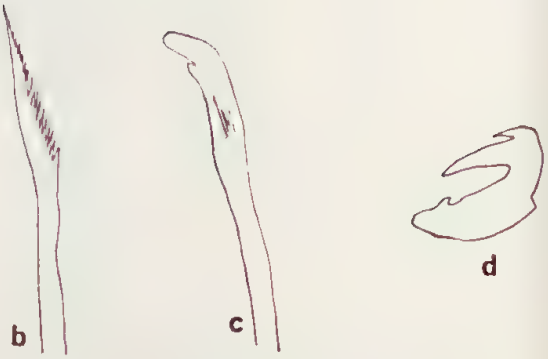

b c d

Fig. 8. *Hadrachaeta aspeta* n.g., n.sp. a. Lateral view of anterior end. b. Notoseta. c. Uncinus from 1st thoracic uncinigerous segment. d. Avicular uncinus.

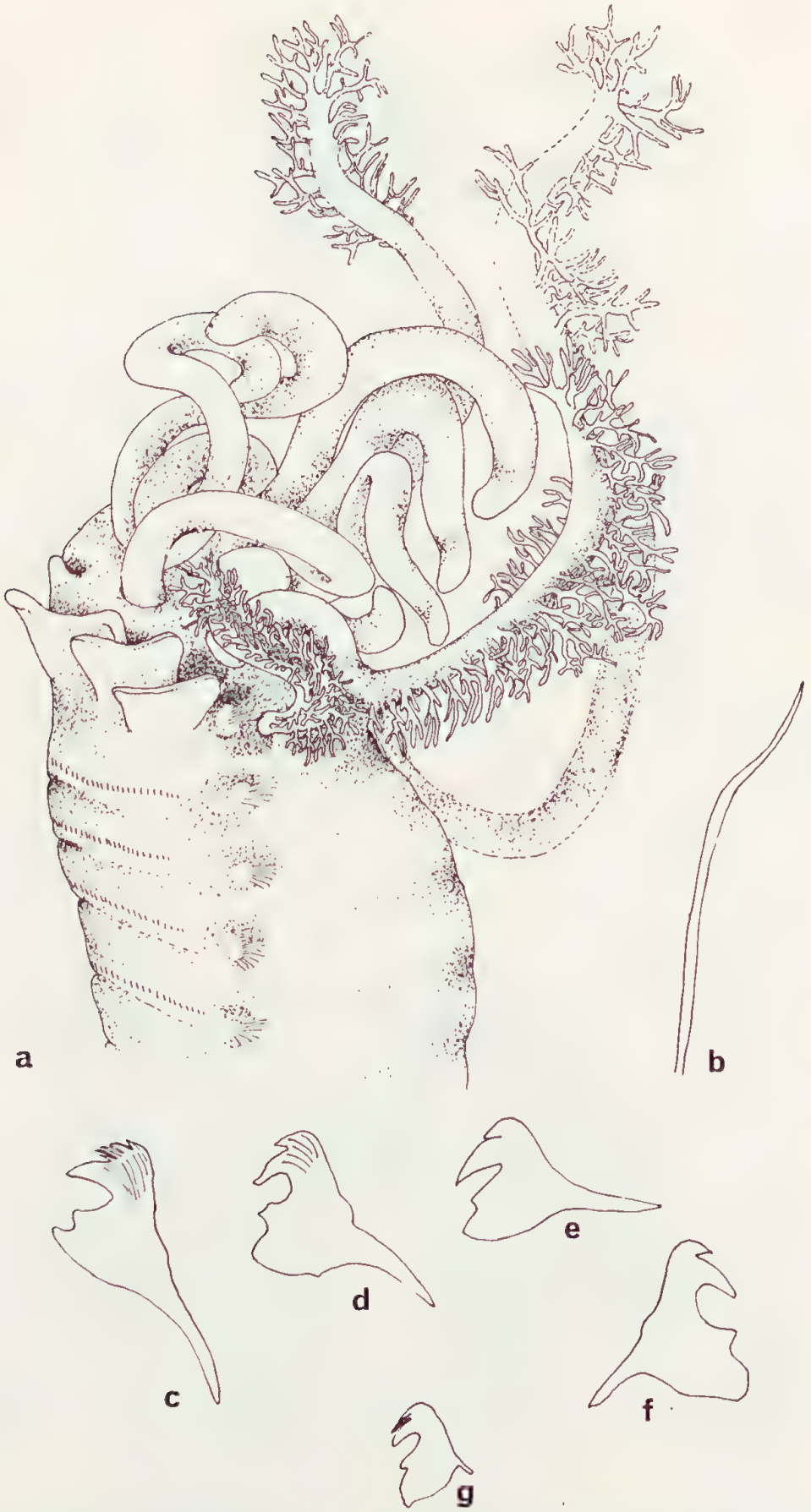

Fig. 9. *Pista pectinata* n.sp. a. Lateral view of anterior end. b. Thoracic notoseta. c. Uncinus from 1st uncinigerous segment. d. Uncinus from 6th uncinigerous segment. e. Uncinus from 10th uncinigerous segment. f. Uncinus from last thoracic segment. g. Uncinus from 1st abdominal segment.

Fig. 10. *Pista trunca* n.sp. a. Dorsolateral view of anterior end. b. Capillary notoseta. c. Uncinus of 1st thoracic uncinigerous segment. d. Uncinus of 6th uncinigerous segment. e. Uncinus of last thoracic segment. f. Uncinus of 1st abdominal segment.

Fig. 11. *Pista trina* n.sp. a. Lateral view of anterior end. b. Capillary notoseta. c,ci. Lateral and face on views of uncinus of 1st thoracic uncinigerous segment. d. Uncinus from 6th uncinigerous segment. e. Uncinus from 1st abdominal segment.

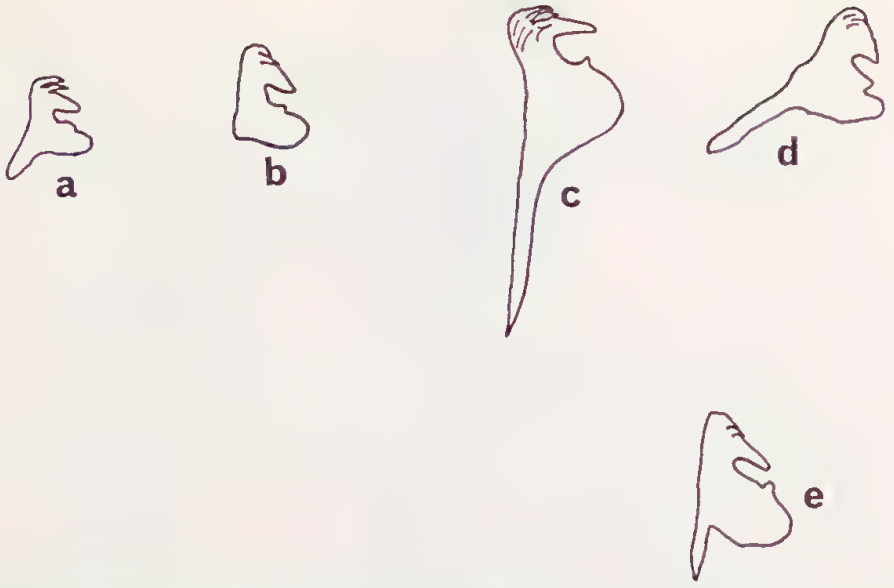

Fig. 12. *Pista typha* a. Uncinus of 1st thoracic uncinigerous segment. b. Uncinus of 6th uncinigerous segment. *Pista cristata* c. Uncinus of 1st thoracic uncinigerous segment. d. Uncinus of 10th uncinigerous segment. e. Uncinus of last thoracic segment.

Fig. 13. *Artacamella dibranchiata* a. Posterior thoracic uncinus. b,c. Lateral and face on view of abdominal uncinus.

PONTONIINE SHRIMPS IN THE COLLECTIONS OF THE AUSTRALIAN MUSEUM

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SUMMARY

The report provides details of twenty four species of pontoniine shrimp in the collections of the Australian Museum, principally from the Great Barrier Reef region of Queensland. Two new species are described and illustrated, *Anchistus custoides* sp.nov., and *A. australis* sp.nov., both associates of bivalve molluscs. Seven species are also added to the Australian fauna. Twenty species are considered to be obligate commensals of other marine invertebrates and where possible the hosts are identified. An unusual post-larval specimen, *?Araiopontonia* sp., associated with a crinoid, is also described and illustrated.

INTRODUCTION

The pontoniine shrimp fauna of Australia, including the Great Barrier Reef, has been little studied. Shrimps of this subfamily of the Palaemonidae are particularly abundant in tropical and subtropical waters and, with the shrimps of the family Alpheidae, form the dominant components of the caridean fauna of the coral reef biotope. They are also of special interest on account of their wide range of specialized adaptations to living in permanent associations with a wide range of invertebrate host animals.

Spence Bate (1863) was the first to record a pontoniine shrimp from Australian waters. He reported *Anchistia aesopius (=Periclimenes aesopius)* from St. Vincent's Gulf. Most of the Indo-West Pacific species of the subfamily have a wide distribution throughout the region, but *P. aesopius* has not been subsequently reported from any locality outside South Australia. It is probably a commensal species, but its host has not been recorded. The closely related *P. holthuisi* Bruce is associated with a variety of coelenterate taxa and a similar association for *P. aesopius* is probable. The restricted distribution in southern Australia suggests that it may be an endemic relict. Subsequently a few isolated reports concerning mainly single species appeared in the scientific literature, until, in 1966, Patton reported upon sixteen species associated with the Queensland branching corals. In 1968 McNeill reported upon the decapod crustacea from the Great Barrier Reef Expedition, 1928-29, but this included only eight species of the subfamily Pontoniinae (McNeill, 1968). Further records of new species, were reported in Bruce (1969a, 1969b, 1970a), and a further eight species were added to the Australia fauna in Bruce (1971). A small collection of pontoniine shrimps from the vicinity of Townsville was also reported upon by Bruce (in press a).

The present collection provides details of twenty five taxa in the collections of the Australian Museum, Sydney. All except four species are considered to be obligate commensals, and where possible, the hosts of these have been identified. The material was collected by the staff of the museum in the course of their investigations into the ecology of the coral reefs of Queensland. The measurements given refer to the post-orbital carapace length of the specimens (CL.) Full synonymies for most of the species are to be found in Holthuis (1952).

Records of The Australian Museum, 1977, **Vol. 31 No. 2,** 39-81, Figures 1-16

SPECIES CHECK-LIST

Palaemonella Dana, 1852
1. *P. rotumana* (Borradaile, 1898)
2. *P. pottsi* (Borradaile, 1915)

Periclimenes Costa, 1844
3. *P. lutescens* auct.
4. *P. grandis* (Stimpson, 1860)
5. *P. elegans* (Paulson, 1875)
6. *P. amymone* De Man, 1902
7. *P. ceratophthalmus* Borradaile, 1915
8. *P. longirostris* (Borradaile, 1915)

Anchistus Borradaile, 1898
9. *A custos* (Forsskal, 1775)
10. *A. gravieri* Kemp, 1922
11. *A. demani* Kemp, 1922
12. *A. custoides* sp. nov.
13. *A. australis* sp. nov., forma *typica*
14. *A. australis* sp. nov., forma *dendricauda*

Philarius Holthuis, 1952
15. *P. gerlachei* (Nobili, 1905)

Ischnopontonia Bruce, 1966
16. *I. lophos* (Barnard, 1962)

Harpiliopsis Borradaile, 1915
17. *H. depressa* (Stimpson, 1860)

Coralliocaris Stimpson, 1860
18. *C. superba* (Dana, 1852)
19. *C. venusta* Kemp, 1922
20. *C. viridis* Bruce, 1974

Jocaste Holthuis, 1952
21. *J. lucina* (Ortmann, 1890)
22. *J. japonica* (Nobili, 1901)

Conchodytes Peters, 1852
23. *C. tridacnae* Peters, 1852
24. *C. meleagrinae* Peters, 1852

Incertae sedis
25. *?Araiopontonia* sp.

SYSTEMATIC ACCOUNT

1. **Palaemonella rotumana** (Borradaile)

Restricted synonymy:

Periclimenes (Falciger) rotumanus Borradaile, 1898: 1005, pl. 63.

Periclimenes (Harpilius) rotumanus — McNeill, 1968: 7,22.

Palaemonella vestigialis Kemp, 1922: 123-126, figs. 1-2, pl. 3 fig. 2. Holthuis, 1952: 8, 24, fig. 3.

MATERIAL EXAMINED: 1 ovig. ♀, CL 2.2 mm, North East Cay, Herald Group, 9 November 1964. 1♂, CL. 3.7 mm, One Tree Is., Capricorn Group, November 1966.

HABITAT/HOST: No data.

DISTRIBUTION: Common and widespread throughout the whole Indo-West Pacific region, and has extended its range through the Suez Canal into the western Mediterranean Sea. Type locality, Rotuma, Fijian Islands.

REMARKS: The specimens correspond closely to Kemp's redescription. The female has six dorsal and two ventral rostral teeth, with the posterior two teeth situated on the carapace. The male has seven dorsal rostral teeth, the most distal being subapical, and two ventral teeth. The rostrum distinctly exceeds the antennular peduncle in the male, but is slightly shorter in the female. The post-orbital ridge is well marked in both specimens but bears no trace of the characteristic small tubercle reported by Kemp. The female specimen lacks both the second pereiopods, which are present in the male and show a strong acute terminal spine on the distal dorsal border of the carpus, with a smaller blunter angulation medially. The female carried only 15 undeveloped ova, maximum length 0.5 mm.

The first record of this common species in Australian waters appears to be that of McNeill (1968) from the Low Isles, as *Periclimenes rotumanus*. This specimen has been re-examined and the presence of the mandibular palp confirmed. This species has also been recorded from Moreton Bay, Queensland.

2. **Palaemonella pottsi** (Borradaile)

Restricted synonymy:

Periclimenes (Falciger) pottsi Borradaile, 1915: 213; 1917, 374.

Periclimenes pottsi — Potts, 1915: 75, 81, 82.

Palaemonella pottsi — Kemp, 1922: 126-127. Holthuis, 1952: 7. Johnson, 1961: 57-58, 62, 63, 75, tab. 1. Bruce, 1970: 279-284, figs. 1, 3-7, pl. 1 figs. a-d.

MATERIAL EXAMINED: 1♂, CL. 3.6 mm, One Tree Island, 140 ft, 28 November 1966, coll. F. Talbot.

HOST — *Comanthina schlegeli* (P. H. Carpenter) (Echinodermata: Crinoidea).

DISTRIBUTION: Type localities, Mabuaig and Murray Island, Torres Strait. Also recorded from Singapore, New Caledonia, the Marshall Islands, Zanzibar and Kenya.

REMARKS: This specimen has been previously referred to in Bruce (1970). The rostrum bears eight well developed dorsal and three ventral rostral teeth, the two posterior dorsal teeth being situated on the carapace. All pereiopods are detached but all except one of the first pereiopods are present.

Potts reported that this species was abundant at Murray Island but scarce at Mabuaig. The specimens were found in association with a *Comanthus* sp. In the case of the present specimen, a post-larval juvenile of ?*Araipontonia* sp. (see below) was found in association on the same host.

3. **Periclimenes lutescens** auct.

Restricted synonymy:

?*Harpilius lutescens* Kemp, 1922: 229 (key), 235-237, figs. 72-73.

Periclimenes (Harpilius) lutescens — Patton, 1966: 275, 288 (tab. 1), 290 (tab. 2).

Periclimenes lutescens — Bruce, 1971a: 2, 5; 1972: 409, 411, 412 (key), fig la; 1975: 27, fig. 15.

MATERIAL EXAMINED: 1 juv. ♀, CL 2.1 mm, Gillett Cay, Swains Reefs, October 1962.

HOST: *Seriatopora* sp. (Scleractinia)

DISTRIBUTION: Kemp reported upon specimens from the Red Sea, recorded by Tattersall (1921) as *Harpilius depressus*. The type locality for Dana's *Harpilius lutescens* s. str., is Tongatabu, Tonga Islands. Also recorded from Madagascar, Comoro and Seychelle Islands, Zanzibar, Tanganyika and Kenya in the Indian Ocean. Also from Singapore, Indonesia and Japan (as *P. amamiensis* Kubo). First recorded from the Great Barrier Reef by Patton (1966) from Restoration Rock, Heron Island and Wistari Reef.

REMARKS: The association with *Seriatopora* is unusual for this species, which is normally associated with corals of the genus *Acropora*. In other pontoniine species, juveniles may occasionally be found in what must be considered as atypical hosts, but Patton's Willis Island specimens were also associated with *S. hystrix* (Dana).

The rostrum has seven dorsal and two ventral teeth and extends well beyond the antennular peduncle and also exceeds the scaphocerite. A distinct median spine is present ventrally on the fourth thoracic sterite. The dorsal telson spines are robust, the anterior pair at the middle of the telson length and the posterior pair at 0.75 of the telson length. The tip of the telson slightly exceeds the endopods of the uropods. The fingers of the second pereiopods are not particularly bent inwards as described by Kemp and the dentition of the cutting edges is more feeble than shown in his illustration.

4. **Periclimenes grandis** (Stimpson)

Restricted synonymy:

Anchistia grandis Stimpson, 1860: 34.

Periclimenes (Ancylocaris) grandis — Kemp, 1922: 171 (key), 210-214, figs. 58-59, pl. 7 fig. 10.

Periclimenes (Harpilius) grandis — Holthuis, 1952: 11, 79-81.

MATERIAL EXAMINED: 2♀ (1 ovig.), CL 3.5 mm, Picnic Bay, Magnetic Island, 1 November, 1964.

HABITAT: Under dead coral, on sandy mud flat.

DISTRIBUTION: Type locality, Oshima, Japan. Common and wide-spread in the Indian Ocean and western Pacific Ocean to Indonesia and Japan. Not previously recorded from Australian waters.

REMARKS: The non-ovigerous female is infected by a hemiarthrinid bopyrid parasite.

5. **Periclimenes elegans** (Paulson)

Restricted synonymy:

Anchistia elegans Paulson, 1875: 113, pl. 7 fig. 1.

Periclimenes (Ancylocaris) elegans — Kemp, 1922: 171 (key), 215-218, figs. 60-63.

Periclimenes (Ancylocaris) elegans var. *dubius* — McNeill, 1926: 300.

Periclimenes (Harpilius) elegans — Holthuis, 1952: 11, 81-82, fig. 31. McNeill, 1968: 7, 22.

MATERIAL EXAMINED: 1♂, 1 ovig. ♀, 5 juv., CL 3.8, 3.8, 1.4-2.5 mm, West Cay, Diamond Islets, 24 November 1964.

HABITAT: No data.

DISTRIBUTION: Type locality, Red Sea. Common in the Indian Ocean, Indonesia, to the Palau Islands. Previously recorded from the Low Isles and Northwest Islet in Queensland by McNeill (1926, 1968).

REMARKS: This species is only doubtfully distinct from *P. grandis* (Stimpson), the differences in the armament of the carpus of the second pereiopod are probably mainly due to changes resulting from growth after autotomy.

6. **Periclimenes amymone** De Man

Restricted synonymy:

Periclimenes amymone De Man, 1902: 829-833, pl. 25 fig. 53.

Periclimenes (Harpilius) amymone — Holthuis, 1952: 10, 82-83, fig. 32. Patton, 1966: 273, 288 tab. 1, 290 tab. 2, 291 tab. 3.

MATERIAL EXAMINED: 1 ovig. ♀, CL. 2.4 mm, no data. 1♂, One Tree Island, November 1966.

HABITAT/HOST: No data.

DISTRIBUTION: Type locality, Ternate, Indonesia. Also recorded from the Nicobar Islands, New Caledonia and Samoa. Recorded from Bet Reef, Restoration Rock, Heron Island, Wistari Reef and Moreton Bay, Queensland, by Patton (1966).

REMARKS: Of the shrimps studied by Patton (1966), this species was the only coral commensal to be found normally in association with both acroporid and pocilloporid corals. The ovigerous female carried 61 ova, greatest length 0.48 mm.

7. **Periclimenes ceratophthalmus** Borradaile (Fig. 1.)

Restricted synonymy:

Periclimenes ceratophthalmus Borradaile, 1915: 211; 1917: 324, 365, pl. 54 figs. 9a-b. Bruce, 1974: 192-193, fig. 2.

Periclimenes (Periclimenes) ceratophthalmus — Kemp, 1925: 325-325, fig. 18. Holthuis, 1952: 8, 56-57, fig. 20. Miyake & Fujino, 1968: 402-403, 431, fig. 2a-d.

MATERIAL EXAMINED: 1♂, CL. 2.4 mm, One Tree Island, Capricorn Group, 28 November 1962.

DESCRIPTION: A slender elongated shrimp with smooth carapace and abdomen.

The rostrum is long and slender, extending slightly beyond the antennular peduncle. The dorsal margin is convex and bears three small acute teeth on the distal quarter. The ventral margin is also convex but devoid of teeth. The midrib is well developed and is expanded and concave posteriorly where it is continuous with the superior orbital margin. The superior orbital margin is a broad lamina and bears a large acute supra-ocular spine. The inferior orbital angle is blunt and slightly produced. The antennal spine is small and slender and directed upwards, arising from the anterior margin of the carapace close to the inferior orbital angle. The lateral margin of the orbit is distinct and is continuous with the hepatic spine which is situated close to the antennal spine. The hepatic spine is directed anteriorly and is larger and more robust than the antennal spine. The antero-lateral margin of the carapace is not produced and is bluntly rounded.

The third abdominal segment is not produced posteriorly in the dorsal midline. The fifth segment is 0.6 times the length of the sixth, which is 1.2 times longer than its average depth. The posterior angle is well produced and acute. The postero-lateral angle is less markedly produced and blunter. The pleura of the first five segments are rounded. The telson is 1.6 times the length of the sixth abdominal segment. The tip is slightly damaged. The

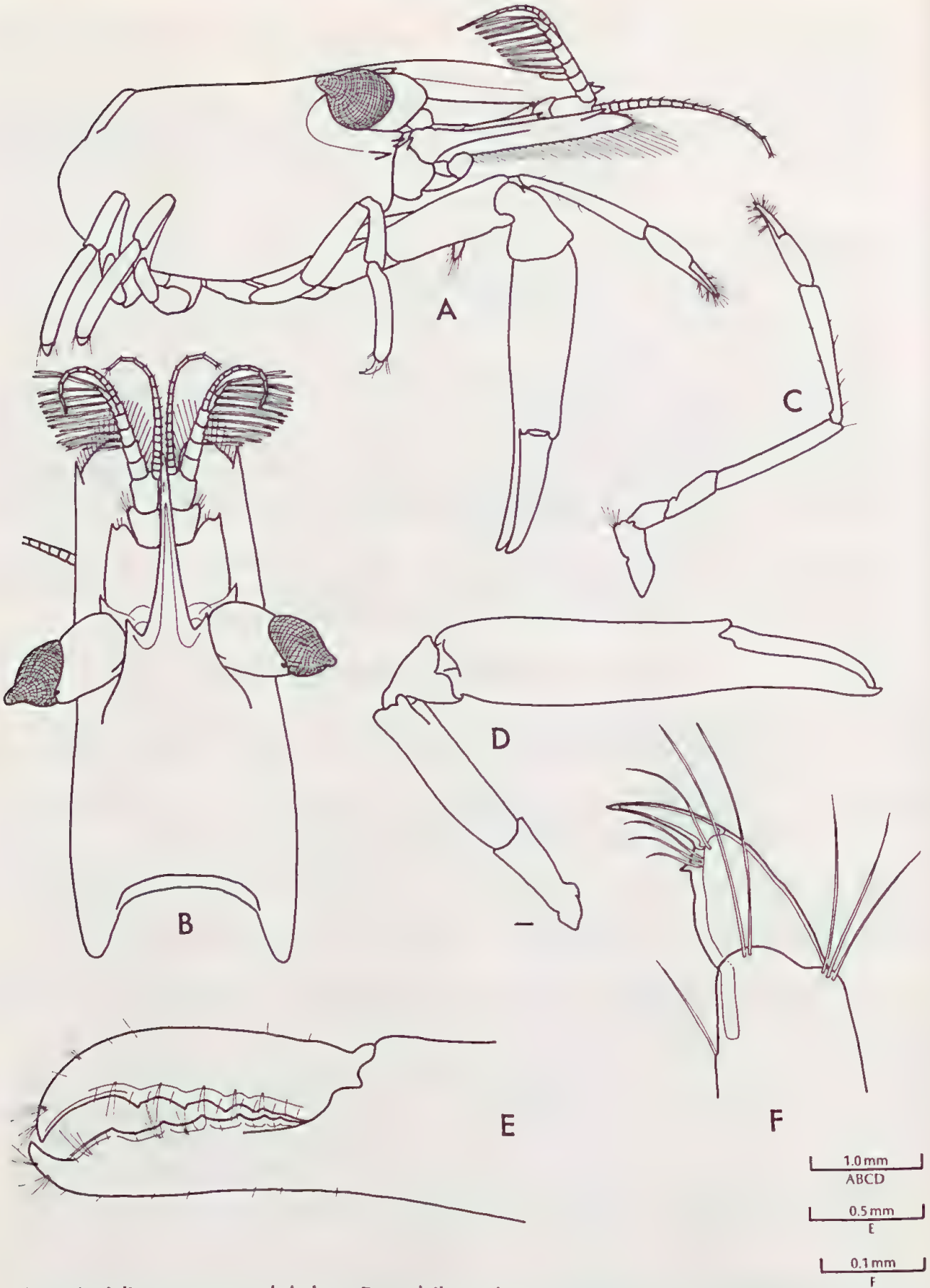

Fig. 1. *Periclimenes ceratophthalmus* Borradaile, male. A, carapace and appendages, lateral view. B, dorsal view. C, first pereiopod. D, second pereiopod. E, fingers of second pereiopod. F, dactylus of ambulatory pereiopod.

anterior pair of dorsal spines are situated close to the lateral margin of the telson at about the middle of its length. The posterior dorsal spines lie halfway between the anterior pair and the tip of the telson. The dorsal spines are slightly smaller than the lateral posterior telson spines. The intermediate spines are long and robust, distally blunt and equal to about one quarter of the length of the telson. The submedian spines are about half the length of the intermediate spines and are slender, acute and non-setose. The lateral spines are about 0.2 times the length of intermediate spines.

The antennular peduncle is exceeded by the rostrum and reaches the level of the base of the antero-lateral spine of the scaphocerite. The proximal segment is about twice as long as wide. The stylocerite is well developed and acute, reaching to about the middle of the medial border of the segment. The antero-lateral margin is strongly produced and reaches to a level of 0.6 of the length of the intermediate segment of the peduncle. The antero-lateral lobe bears a medial lobe and a small lateral tooth. The intermediate and distal segments are subequal in length and equal to about two-thirds of the length of the basal segment. The intermediate segment has a well developed antero-lateral lobe. The lower antennular flagellum is short and filiform, consisting of fifteen cylindrical segments. The upper and lower rami of the upper flagellum are fused proximally for four segments. The shorter free ramus consists of two segments and the longer ramus of twelve segments. There are ten groups of aesthetascs.

The antennal flagellum is well developed and extends to the base of the telson. The carpocerite is subcylindrical and short, reaching to a point halfway between the tip of the stylocerite and the proximal end of the intermediate segment of the antennular peduncle. The merocerite and ischiocerite are normal and the basicerite bears a small acute dorso-lateral spine. The scaphocerite bears a large slender disto-lateral tooth. The lateral margin is straight. The lamella extends beyond the disto-lateral tooth and exceeds the tip of the rostrum, and is bluntly angled.

The eyes are well developed with large globular corneae that are produced distally to form a conoidal process. The cornea is situated obliquely on the eyestalk which is about 1.5 times longer than wide. A distinct accessory pigment spot is present close to the dorso-lateral corneal margin.

The mouthparts have not been dissected.

The first pereiopod is slender and exceeds the scaphocerite by the chela and the distal quarter of the merus. The fingers of the chela are slender with entire cutting edges, and equal to 0.8 of the length of the palm. The carpus is 1.3 times the length of the chela and is broader distally than proximally. The merus us subequal to the carpus. The ischium is half the length of the merus and the basis is two-thirds of the length of the ischium. The coxa lacks a medial process. The second pereiopods are well developed and robust. The chelae are similar but unequal, (64 : 50). The palm of the major chela is sub-cylindrical, slightly swollen proximally. The fingers are stout and equal to slightly more than half the length of the palm, (22 : 42). The dactylus is curved and the posterior two-thirds of the cutting edge bears four low acute teeth. The anterior part, which is entire, fits into a notch between the strongly hooked tip and the cutting edge of the fixed finger. The posterior three quarters of the cutting edge of the fixed finger bears a series of six teeth, which decrease in size proximally. The carpus is short, stout and unarmed, equal to about one fifth of the length of the chela. The merus is equal to two fifths of the length of the chela. It is flattened proximally and the upper and lower distomedial regions are produced as blunt lobes. The ischium is flattened and equal to two thirds of the length of the merus. The minor second pereiopod is generally similar to the major, apart from the smaller size of the carpus and chela, in which the fingers are equal about four-fifths of the length of the palm (22 : 28). The fingers are more slender and more feebly armed. The ambulatory pereiopods are moderately robust. In the third pereiopod the dactylus is short and stout, curved, with a distinct unguis. A small accessory spine is present on the posterior border close to the base of the unguis. Several

setae arise from the disto-lateral aspect of the dactylus. The propodus is 5.4 times longer than wide, tapering slightly, with a few long setae distally. The lengths of the segments from dactylus to ischium are in the ratios, 10 : 42 : 26 : 40 : 31. All segments are unarmed. The sternite of the fourth thoracic somite lacks a median process.

The uropods extend posteriorly beyond the tips of the telson spines. The rami are narrow and the exopod slightly exceeds the endopod. The lateral margin of the exopod is feebly convex and bears a large mobile distal spine.

HOST: *Himerometra robusta* (P.H. Carpenter) (Echinodermata, Crinoidea).

DISTRIBUTION: Type locality, Hulule, Male Atoll, Maldive Islands. Subsequently recorded from the Maldive Islands by Kemp (1925), Indonesia and Palau. Reference to the occurrence of this species in the Torres Straits in Bruce (1974) is erroneous, and refers to *P. commensalis*. Also recorded recently from Zanzibar, Kenya and the Seychelle Islands.

REMARKS: A considerable amount of minor morphological variation appears to occur in this species. Borradaile's description is brief and the illustrations incomplete. The holotype is now without the ambulatory pereiopods (Goodhart, *in litt.*) and the morphology of the dactylus of the walking legs is not known. In the present material and that of Fujino and Miyake from Palau, the accessory spine is very small, but the material from Farquhar (Bruce, 1974) and Kemp's specimen from the Maldive Islands show a large acute accessory spine. Kemp also notes that the dactylus is partly concealed by long setae on the distal end of the propod but these are not present in the Palau or One Tree Island specimens. The shape of the conoidal projection of the cornea is also subject to variation, but only Kemp's and Holthuis's material show the extreme form where the total length of the cornea is equal to that of the eyestalk, which is more than twice as long as wide. Holthuis (1952) has noted that, in his Indonesian specimen, the dorsal telson spines are particularly small, and this is apparently also found in the Palau material but clearly not present in the specimens from Farquhar or One Tree Island. The single Australian specimen appears to be most similar to the specimens from Palau.

8. **Periclimenes longirostris** (Borradaile)

Restricted synonymy:

Palaemonella longirostris Borradaile, 1915: 210; 1917: 323, 357, 359, pl. 53 fig. 5.

Periclimenes (Ancylocaris) proximus Kemp, 1922: 171 (key), 201-204, (51-53, figs.)

Periclimenes (Harpilius) longirostris — Holthuis, 1958: 3-6, fig. 1.

MATERIAL EXAMINED: 1♀, CL. 2.0 mm, North East Cay, Herald Group, 9 November 1964.

DISTRIBUTION: Type locality, Salomon Island, Fadiffolu Atoll, Maldive Islands. Subsequently recorded from the Red Sea, Maldive Islands, Seychelle Islands, Andaman Islands, and Papua. Not previously recorded from Australian seas.

REMARKS: The single example agrees well with the descriptions of Kemp (1925) and Holthuis (1958). The rostrum has eight dorsal and two ventral teeth. The two posterior dorsal teeth are situated on the carapace and the distal dorsal tooth is subapical. A slender median spine is present ventrally on the fourth thoracic sternite. The fourth and fifth pairs and the right third pereiopods are lacking. In the second pereiopods the relative proportions of the segments are: —

	dactyl	propod	carpus	merus	ischium
left	50	125	77	67	60
right	48	117	76	68	60

The cutting edge of each finger bears a pair of feebly developed teeth.

9. **Anchistus custos** (Forsskål)

Restricted synonymy:

Cancer custos Forsskal, 1775: 94

Anchistus inermis Miers, 1884: 291, pl. 32B. Rathbun, 1914: 656. Hedley, 1924: 146. Hale, 1927: 47, fig. 52.

Anchistus custos — Holthuis, 1952: 13, 105-109, figs. 33-34. McNeill, 1968: 7, 21. Bruce (in press a).

MATERIAL EXAMINED: 1 ovig. ♀, CL. 6.1 mm, Gillett Cay, Swains Reefs, 1962.

HABITAT/HOST: Not recorded.

DISTRIBUTION: Type locality, Lohei, Red Sea. Widespread and common in the Indo-West Pacific from the Red Sea and Mocambique to Fiji. Previously recorded in Australian waters from the Monte Bello Islands, Sharks Bay, St. Vincent's Gulf, Port Molle, Bowen and the Low Isles.

REMARKS: The specimen agrees precisely with the published descriptions except that of Kubo (1940). Previous Australian records of the species from St. Vincent's Gulf, Bowen and the Low Isles report the association of this species with bivalve molluscs of the genus *Pinna*.

The thoracic sternites are broad. The fourth is unarmed and the fifth forms a low transverse ridge posteriorly to the coxae of the second pereiopods. The dorsal surface of the dactylus of the ambulatory pereiopods is quite smooth and the dorsal telson spines are minute. The cannulate chela of the first pereiopod is well developed and there is no trace of any rostral teeth. The ova are numerous and small, about 0.42 mm. in length.

10. **Anchistus gravieri** Kemp. (Figs. 2-3).

Anchistus gravieri Kemp, 1922: 249 (key), 252-255, figs. 82-84. Holthuis, 1952: 13.

nec Anchistus gravieri — McNeill, 1953: 89.

MATERIAL EXAMINED: 3 pairs, 21 October 1964; 26, 3 ovig. ♀, 24 October 1964; West Cay, Diamond Islets. 1 ovig. ♀, North East Cay, Herald Group, 12 November 1964.

MEASUREMENTS: CL. males 2.5-4.1 mm; females 3.7-8.0 mm. Smallest ovigerous female 6.1 mm.

HOST: *Hippopus hippopus* (L.) (Lamellibranchia, Tridacnidae).

DISTRIBUTION: Type locality, Vanikoro, Santa Cruz Islands.

REMARKS: This species is previously known only from the type material. The specimen referred to this species by McNeill (1953) has been re-examined and found to have a mobile hepatic spine, belonging therefore to the genus *Paranchistus* Holthuis, and the pair of specimens, obtained from *Pinna* sp., should be referred to *P. nobilii* Holthuis.

The specimens agree well with Kemp's original description but some small differences may be noted. In these Australian specimens the number of dorsal rostral teeth shows some variation; males: 3(3), 4(1), females: 2(4), 3(3). In one female the antennal spine was lacking from one side of the carapace. Kemp also reports that the basicerite bears a small tooth but this was not present in any of the specimens examined. Kemp reports that the fingers of the first pereiopods are somewhat subspatulate. In the present specimens the fingers of the first pereiopods are strongly subspatulate or even spatulate and have finely pectinate cutting edges. The dactyls of the ambulatory pereiopods also have a very clearly defined unguis, the proximal margin of which is not shown in Kemp's figure. The holotype of Kemp's species is preserved in the collections of the Museum National d'Histoire Naturelle and, through the

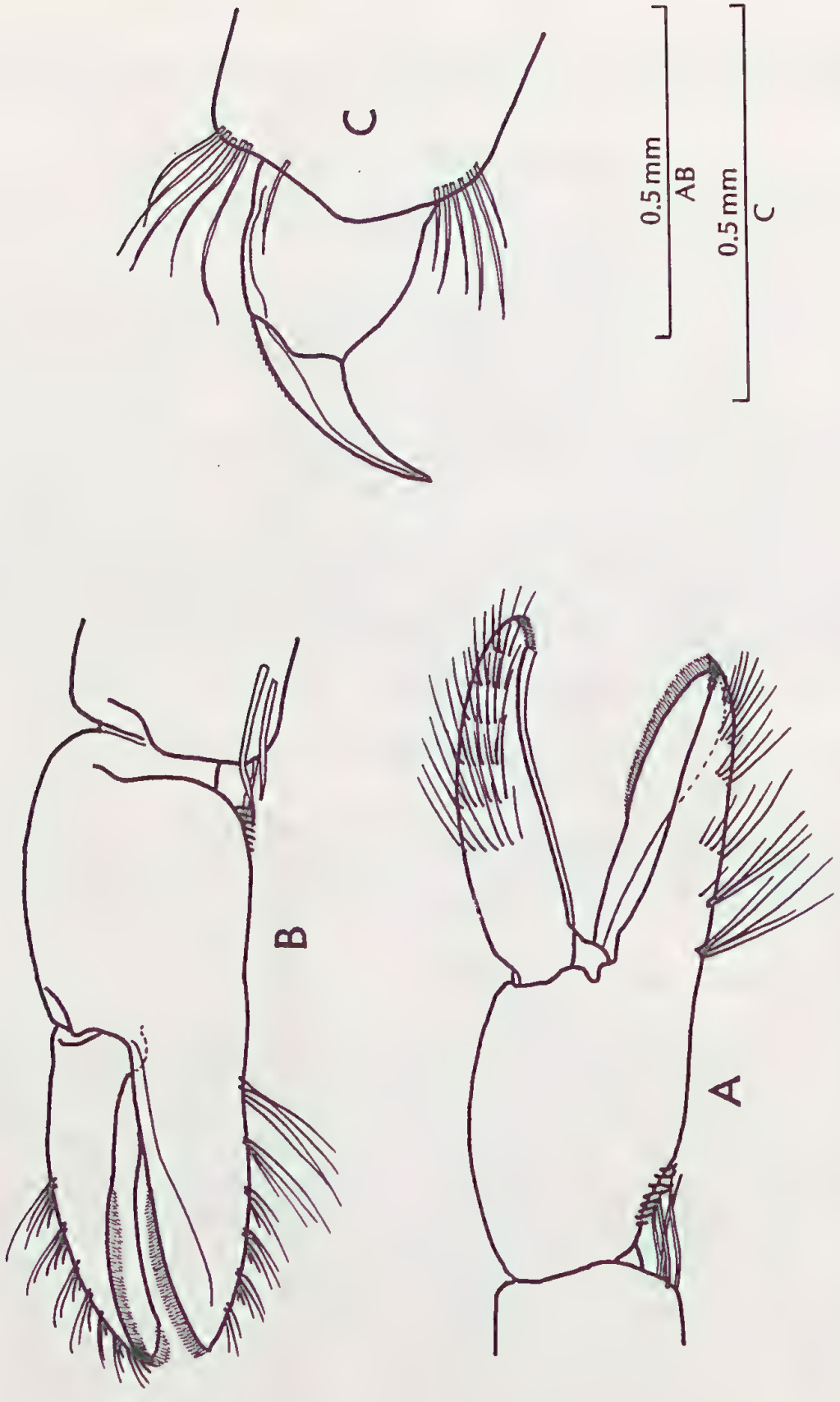

Fig. 2. Anchistus gravieri Kemp, holotype. A, chela of first pereiopod, medial view. B, lateral view. C, dactylus of ambulatory pereiopod.

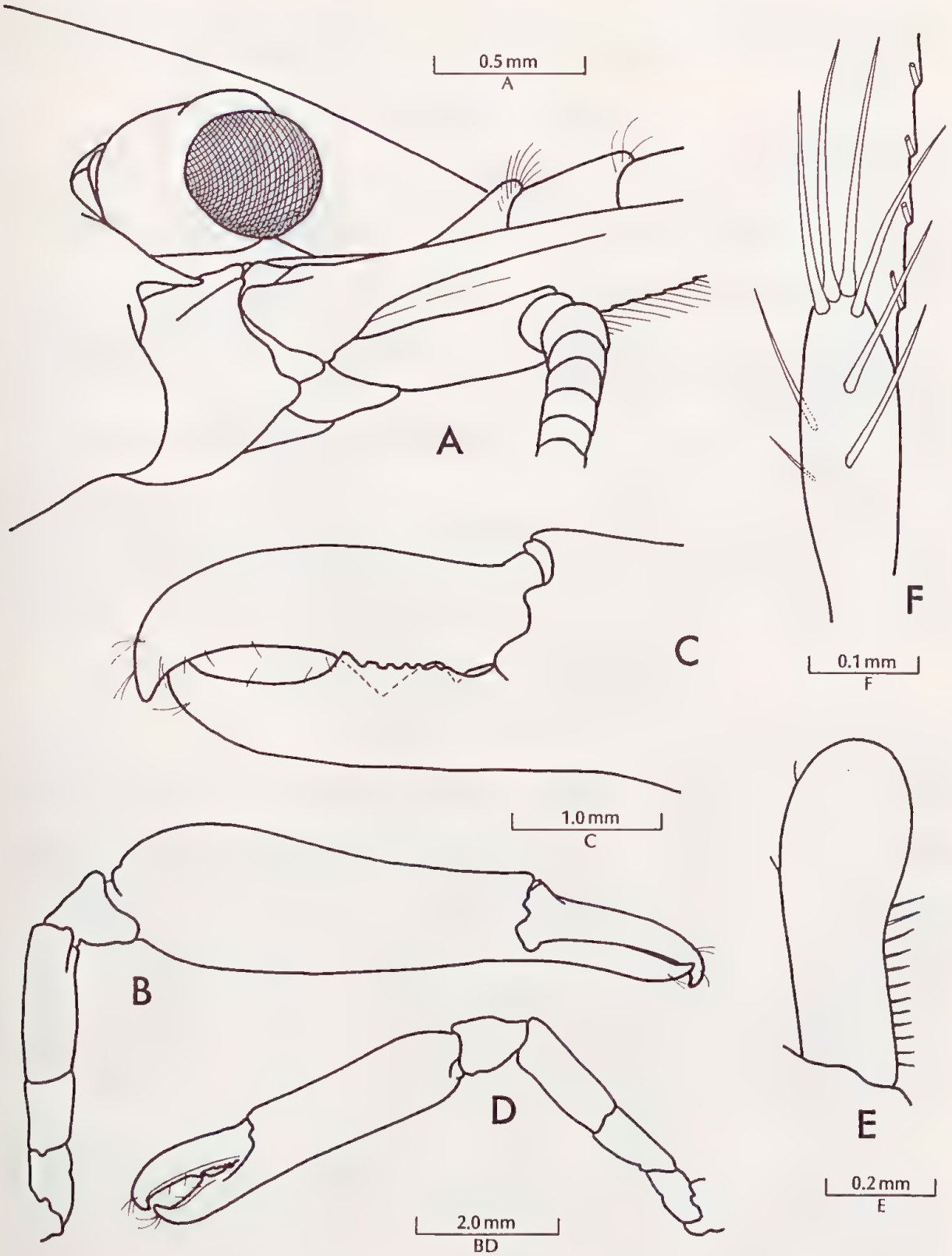

Fig. 3. *Anchistus gravieri* Kemp. A, anterior carapace and proximal antennal segments, female. B, major second pereiopod, male. C, fingers of male major chela. D, minor second pereiopod, male. E, endopod of male first pleopod. F, appendix masculina.

courtesy of Dr. J. Forest, has been re-examined, the pereiopods being found to agree exactly with those of the Australian specimens. *Anchistus miersi* (De Man), usually found in association with *Tridacna squamosa*, has also been reported in association with *Hippopus hippopus* in the Marshall Islands by Holthuis (1953) and Fankboner (1972).

11. **Anchistus demani** Kemp

Restricted synonymy:

Anchistus demani Kemp, 1922: 249 (key), 256-259, figs. 86-88.

MATERIAL EXAMINED: 1♂, CL. 3.1 mm, One Tree Island, Capricorn Group, December, 1966.

HOST: *Tridacna maxima* (Röding) (Lamellibranchia, Tridacnidae).

DISTRIBUTION: Type locality, Port Blair, Andaman Islands. Also recorded from the Marshall Islands, Thailand, the Seychelle Islands, Zanzibar, Kenya and Madagascar. Not previously recorded from Australian waters.

REMARKS: This species has been previously recorded in association with *Tridacna maxima*, which appears to be the typical host.

The rostrum is more obliquely truncate than shown in Kemp's illustration and the pair of teeth are relatively slightly smaller. The inferior orbital angle is also less produced. In all other respects the specimen agrees exactly with Kemp's description. In addition, it may be noted that the fourth thoracic sternite is unarmed and that the posterolateral angle of the protopodite of the uropod is bluntly angled and not acute as in *A. miersi* (De Man).

12. **Anchistus custoides** sp. nov. (Figs. 4-6)

Anchistus inermis — Kubo, 1940: 48-51, figs. 15-17.

?*Anchistus custos* — Miyake & Fujino, 1968: 415-417, 431 tab. 1.

MATERIAL EXAMINED: 1♂, 1 ovig. ♀, CL. 5.2, 9.1 mm, Gillett Cay, Swains Reefs, October 1962. 1♂, 1 ovig. ♀, CL. 3.9, 7.0 mm, One Tree Island, Capricorn Group, November 1966.

DESCRIPTION: The body is robust, with a smooth carapace and rostrum, markedly swollen in the females. The rostrum is broad proximally, compressed distally, and also depressed, especially in the females. The rostrum is rounded distally and reaches to a level between the proximal and distal margins of the intermediate segment of the antennular peduncle. The midrib is feebly developed and is continuous posteriorly with the orbital margin. The anterior fourth of the upper margin is blunt and bears four minute teeth in both sexes and the anterior extremity bears one or two minute teeth in the females and two to four in the males. The ventral margin of the rostrum is sharp and generally convex. The inferior orbital angle is bluntly produced. A small acute antennal spine arises from the anterior margin of the carapace well below the level of the inferior orbital angle. Supra-orbital and hepatic spines are absent. The antero-lateral angle of the carapace is broadly rounded.

The third abdominal segment is not posteriorly produced in the dorsal midline. The pleura of the first five segments are broadly rounded. The sixth segment is about 1.4 times as long as the fifth and 1.6 times longer than its depth anteriorly. The posterior ventral angle is pointed and the posterior lateral angle is acutely produced. The telson is about 1.5 times as long as the sixth abdominal segment, about 2.5 times longer than its width anteriorly. The lateral margins are feebly convex and the distal margin is broadly rounded. There are two pairs of well developed dorsal spines, which are slightly longer than the lateral terminal spines. The anterior pair is situated at the beginning of the posterior third of the telson length and the posterior pair lies half way between the anterior pair and the posterior margin. There are three pairs of short robust terminal spines. The lateral pair are about half the length of the intermediate pair, which are swollen except for the distal fourth. The

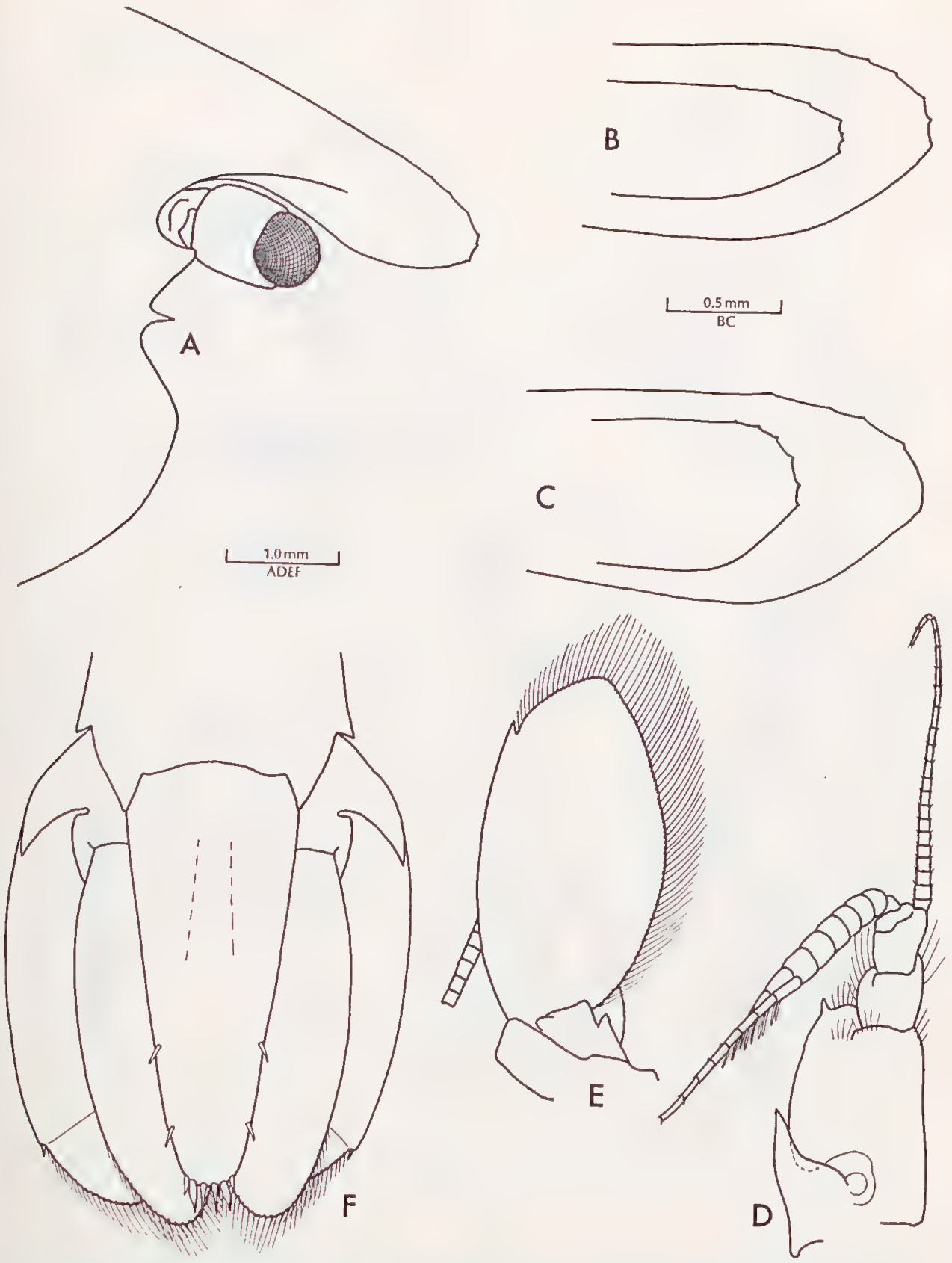

Fig. 4. *Anchistus custoides* sp. nov., A, anterior region of carapace, lateral aspect, female. B, tips of rostra of West Cay pair. C, tips of rostra of One Tree Island pair. D, antennule. E, antenna. F, uropods and telson.

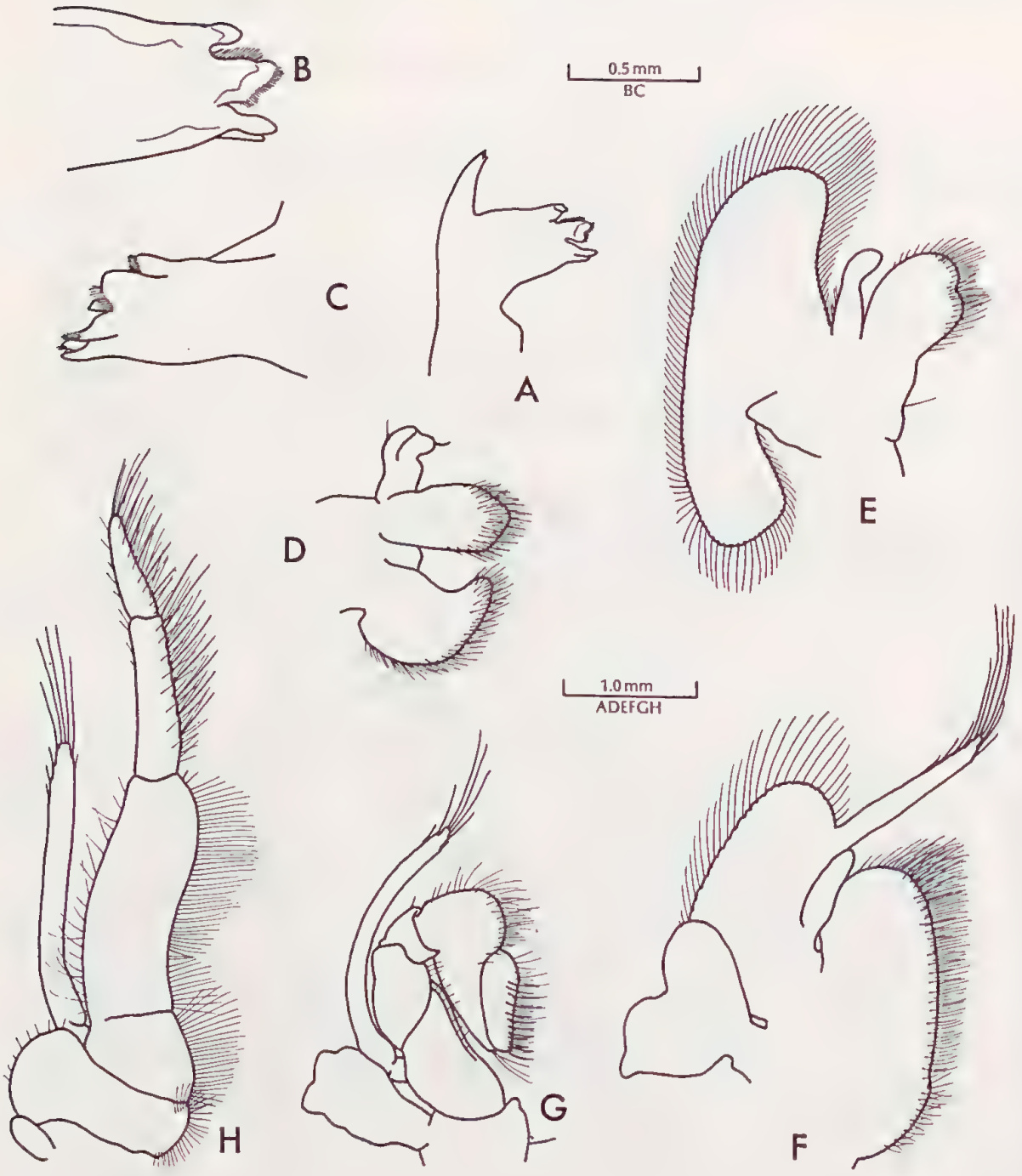

Fig. 5. *Anchistus custoides* sp. nov., A, mandible. B, molar process, ventral view. C, dorsal view. D, maxillula. E, maxilla. F, first maxilliped. G, second maxilliped. H, third maxilliped.

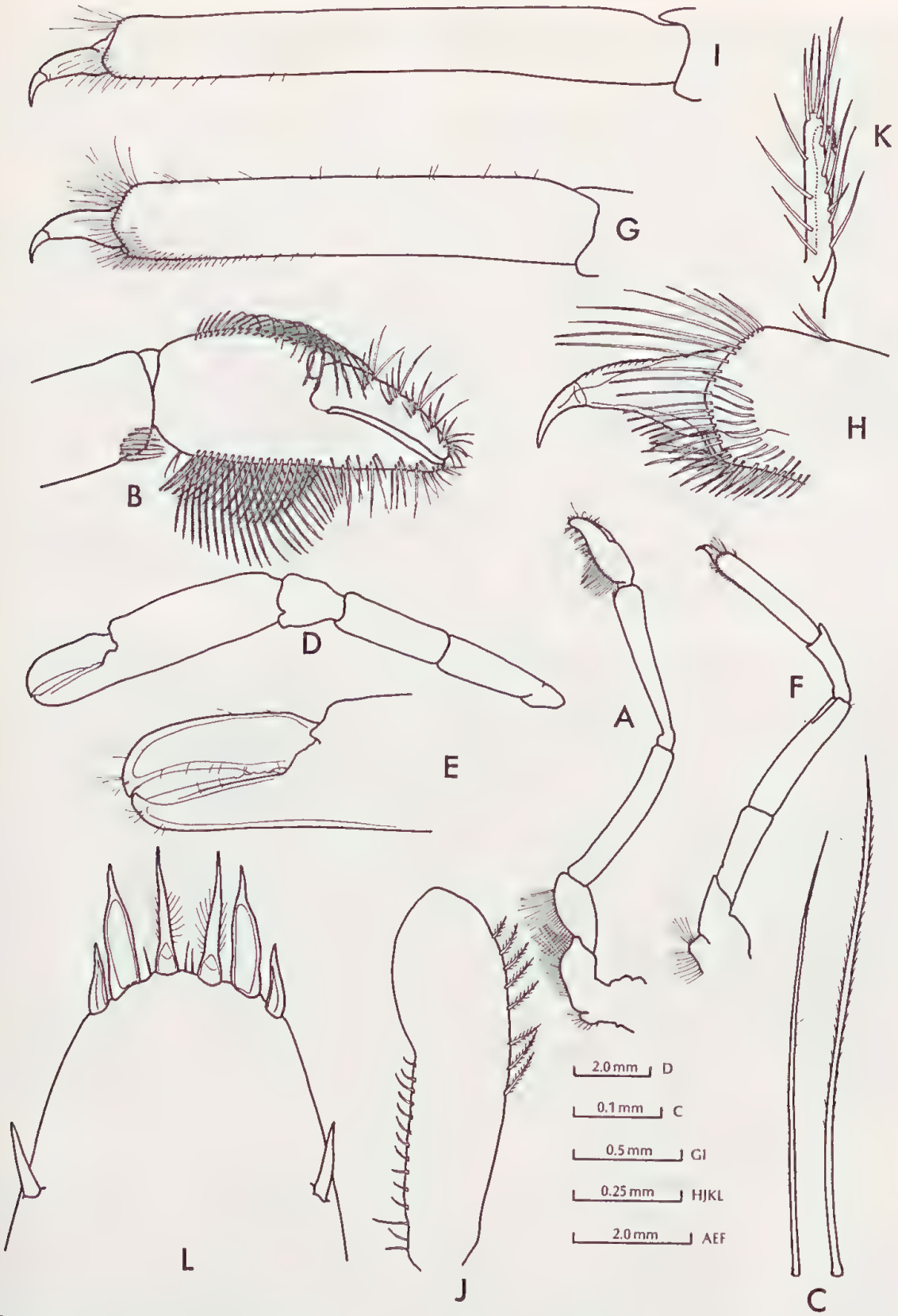

Fig. 6. *Anchistus custoides* sp. nov., female. A, first pereiopod. B, chela of first pereiopod. C, setae from chela of first pereiopod, from palm (left) and fingers (right). D, second pereiopod. E, fingers of second pereiopod. F, third pereiopod. G, dactylus and propodus of third pereiopod. H, dactylus of third pereiopod. I, dactylus and propodus of fifth pereiopod. J, endopod of male first pereiopod. K, appendix interna and appendix masculina. L, tip of telson, female.

submedian spines are also robust but not swollen, slightly shorter than the intermediate spines and sparsely setose. The terminal spines are slightly longer and more slender in the males than in the females.

The eyes are well developed but small. The cornea is hemispherical and lies slightly obliquely on the eyestalk. A small accessory pigment spot is present. The eyestalk is subcylindrical and equal in length to about twice the diameter of the cornea.

The basal segment of the antennular peduncle is broad, one and a half times longer than wide. A well developed broad, acute stylocerite is present, reaching to the level of the middle of the basal segment. The lateral border is convex and the antero-lateral border is produced and bears a small slender acute tooth disto-laterally. A small acute tooth is present halfway along the ventral surface of the medial border. The intermediate and distal segments are stout and subequal, and equal together to about half the length of the basal segment. The lateral margin of the intermediate segment is produced to form a setose lobe. The upper flagellum has its two rami fused proximally for six segments. The shorter ramus consists of about eight segments. The lower ramus is filiferm and consists of nineteen to twenty-four segments.

The basicerite is unarmed laterally and the carpocerite extends to the middle of the lateral border of the scaphocerite. The scaphocerite slightly exceeds the antennular peduncle and is almost twice as long as wide. The lateral border is strongly convex and bears a short stout tooth distally. The lamella distinctly exceeds the disto-lateral tooth and the anterior margin is broadly angled with the convex median border.

The mandible is without a palp. The incisor process is feebly developed and bears three small teeth distally, the central tooth being slightly smaller than the adjacent teeth. The molar process is robust and bears several processes fringed with short setae. The maxillula has the laciniae broadened, the lower more than the upper, and both densely margined with fine setae. The palp has the upper lobe very feebly developed. The lower lobe bears a simple seta. The maxilla bears a single broad but distally notched endite, densely fringed. with fine setae. The palp is well developed, subcylindrical, with a few short setae on its lateral border basally. The scaphognathite is narrow. The first maxilliped shows no indentation between basis and coxa which form a continuous convex border densely fringed with fine simple setae. The palp is subcylindrical and bears a medial subterminal seta. The exopod is well developed with a distinct caridean lobe and a bilobed epipod is present. The second maxilliped shows no special features. A well developed exopod and a subrectangular epipod without a podobranch are present. The endopod of the third maxilliped extends to the mid-length of the carpocerite. The distal segment is slightly less than three quarters of the length of the penultimate segment. The combined length of the penultimate and terminal segments is slightly greater than the length of the antepenultimate segment, which is about three times longer than wide. The median borders of all segments are densely setose, with fine slender setae proximally, and stouter setae distally. The exopod is well developed and slightly exceeds the antepenultimate segment. A rounded epipod and a rudimentary arthrobranch are also present.

The slender first pereiopod exceeds the scaphocerite by the chela in the males, and by one third of the length of the carpus in the females. The chela is slightly less than half the length of the carpus. The fingers are stout and sub-spatulate, subequal to the length of the broad palm, which is flattened medially and convex laterally, with a dense row of long finely plumose setae along the dactylar border and double row of similar setae along the opposite margin of the palm with tufts of serrated setae along the outer border of the fixed finger. The laterally situated cutting edges of the fingers are finely pectinate along the distal halves. The carpus is twice as wide distally as proximally and bears a few cleaning setae disto-ventrally. The merus is subcylindrical and slightly bowed. The ischium and basis are subequal, slightly longer than half the length of the merus, flattened and with a fringe of long slender setae along their ventral margins. The coxa bears a small setose disto-ventral knob. The second pereiopods are small, similar and subequal and in the female, exceeding the carpocerite,

swollen in the proximal half, and about 1.6 times the length of the fingers. The fingers have distinctly hooked tips. The dactylus bears a single acute tooth at one third of the length of its cutting edge and the fixed finger bears a series of four similar small teeth proximally. The rest of the cutting edges of the fingers are entire. The carpus is short and stout, twice as wide distally as proximally, equal to about one third of the length of the palm, and unarmed. The merus and ischium are subequal in length and unarmed. The ambulatory pereiopods are moderately slender and similar. The third pereiopod exceeds the scaphocerite by one third of the length of the propodus. The dactylus is slender, simple, compressed bilaterally, moderately hooked and with a distinct unguis. Its upper surface, proximally to the unguis, is finely ridged transversly. The basal width of the dactylus is about half that of the propodus, which is about six times longer than the dactylus. The propodus is subcylindrical and unarmed, with its distal end notched dorsally and ventrally, and provided with numerous long fine distal setae and disto-ventral brushes of shorter setae. The carpus is equal to three fifths of the length of the propodus and is four sevenths of the length of the merus. The merus is 1.1 times the length of the propodus. Both carpus and merus are unarmed. The fourth pereiopod is similar to the third but is less setose distally. The fifth pereiopod is longer and more slender with relatively sparse setae distally. The propodus is nine times longer than wide and the merus is 0.94 times the length of the propodus. The dactylus of the ambulatory pereiopods can be moved through 180°. The second and third thoracic sternites are broad with low transverse ridges. The fourth sternite is without a median spine. The fifth is the narrowest and forms a low ridge with a feeble median notch immediately posteriorly to the second pereiopods. The sixth to eighth sternites are broad, unarmed and increase in size posteriorly.

The pleopods show no special features. The endopod of the first pleopod in the female is short and straight and distally rounded with numerous plumose setae. In the male the endopod is four times longer than wide and is slightly expanded distally. The proximal fifth of the medial border bears three fine setae, the intermediate two fifths bears eleven short curved spines and the distal border is bare. The distal half of the lateral border bears seven setae. The endopods of the second to fifth pleopods bear appendices internae in both sexes. The endopod of the second pleopod bears an appendix masculina. The appendix bears six spines along its lateral border and four along the medial border, with a group of four spines terminally. All spines are simple. The appendix masculina is slightly longer than the appendix interna. The uropods exceed the tip of the telson. The basipod is produced disto-laterally as a long acute process. The lateral border of the exopod is convex and armed distally with a small mobile spinule. The ova are numerous and small, about 0.6 mm in length.

TYPES: The types are deposited in the collections of the Australian Museum. The ovigerous female from West Cay is selected as the holotype and the male as allotype, registration number P17531.

HOST: *Atrina vexillum* (Born) (Lamellibranchia, Pinnidae).

DISTRIBUTION: Type locality, West Cay, Diamond Islets. Otherwise known only from One Tree Island and the Palau Islands

REMARKS: *Anchistus custoides* is closely related to *Anchistus custos* but may be easily separated from that species by the presence of the following morphological features: —

(1) minute dorsal and distal rostral teeth.

(2) distinct acute antennal spine.

(3) well developed dorsal telson spines.

(4) a more robust penultimate segment of the third maxilliped with a narrower ante-penultimate segment.

(5) a non-cannulate chela on the first pereiopods, with subspatulate fingers with finely pectinate cutting edges, and with upper and lower inner borders of the palm fringed with long plumose setae.

(6) subterminal dorsal region of dactyls of ambulatory pereiopods with fine transverse ridges.

Kubo (1940) described and illustrated some specimens of *Anchistus* in which he reported the presence of some rudimentary microscopical rostral teeth. A distinct antennal spine is visible in illustrations of both male and female and his illustration of the telson shows that the dorsal spines are quite well developed. The first pereiopod is not described but its illustration does not show the characteristic cannulate appearance found in *A. custos*. In its general proportions it resembles that of *A. custoides* but the long marginal palmar setae are not shown. The similar setae found on the ischium are shown however. Kubo's specimens cannot belong to *A. custos* (Forsskål) and must be considered to belong to *A. custoides*. They are unfortunately no longer in existence (Kubo, in litt.) The specimens reported upon by Miyake and Fujino (1968), also from Palau and in association with *Atrina vexillum* are presumably conspecific with Kubo's material and should also be referred to *A. custoides*.

In the Indian Ocean, two species of shrimp have been reported in association with *Atrina vexillum, Anchistus custos* and *Paranchistus ornatus* Holthuis. The latter species appears to be the normal associate of this bivalve. Kemp (1922) recorded *A. custos* in *A. vexillum* in the Andaman Islands and the same association was reported from Zanzibar by Bruce (in Rosewater, 1961), while Hipeau-Jacquotte (1967) has provided detailed information on the associates of *A. vexillum* in Madagascar. Her studies show that *A. custos* may at times occur in numbers in *A. vexillum*, but in central East Africa *P. ornatus* is the normal associate (Bruce in press b.)

Johnson (1966) has shown that the highly specialized chela of the first pair of pereiopods in *A. custos* is associated with the characteristic feeding habits of the shrimp. The modifications in *A. custoides* are similar. When the carpo-meral joint is flexed the chela is brought into opposition to the fringe of long plumose setae that arises from the ventral margins of the ischium and basis, and which appears to form a part of the same mechanism. On account of its specialized feeding mechanism Johnson has suggested that *Anchistus custos* should be separated from all other species and the genus *Anchistus* Borradaile considered monotypic. *Anchistus custoides* however, is intermediate morphologically between *A. custos* and the other species, which are therefore retained in the genus.

13. **Anchistus australis** sp. nov., forma **typica** (Figs 7-9)

MATERIAL EXAMINED: 7♂, 5♀ (4 ovig.), Stn. 1, Gillett Cay, Swain's Reef, October 1962. 1♂, Capre Cay, Swain's Reef, October 1962.

MEASUREMENTS: CL. males 1.3-3.9 mm; females 4.2-5.3 mm. Smallest ovigerous female 4.2 mm.

DESCRIPTION: The body is robust, with a smooth carapace and abdomen, slightly swollen in the ovigerous females. The rostrum is broad proximally and compressed distally, horizontal or slightly depressed, especially in females. The tip is acute, reaching to the middle of the intermediate segment of the antennular peduncle. The midrib is feebly developed. The distal fourth of lamina is armed with four or five long acute teeth in both sexes, with the exception of a single abnormal female which had a toothless rostrum. Ventrally a single small tooth is present close to the tip, although this is absent in one male. Tufts of long setae are present in the spaces between the rostral teeth. The orbit is feebly developed. The inferior orbital angle is bluntly rounded and scarcely produced. Supra-orbital, hepatic and antennal spines are absent. The antero-lateral angle of the carapace is bluntly obtuse.

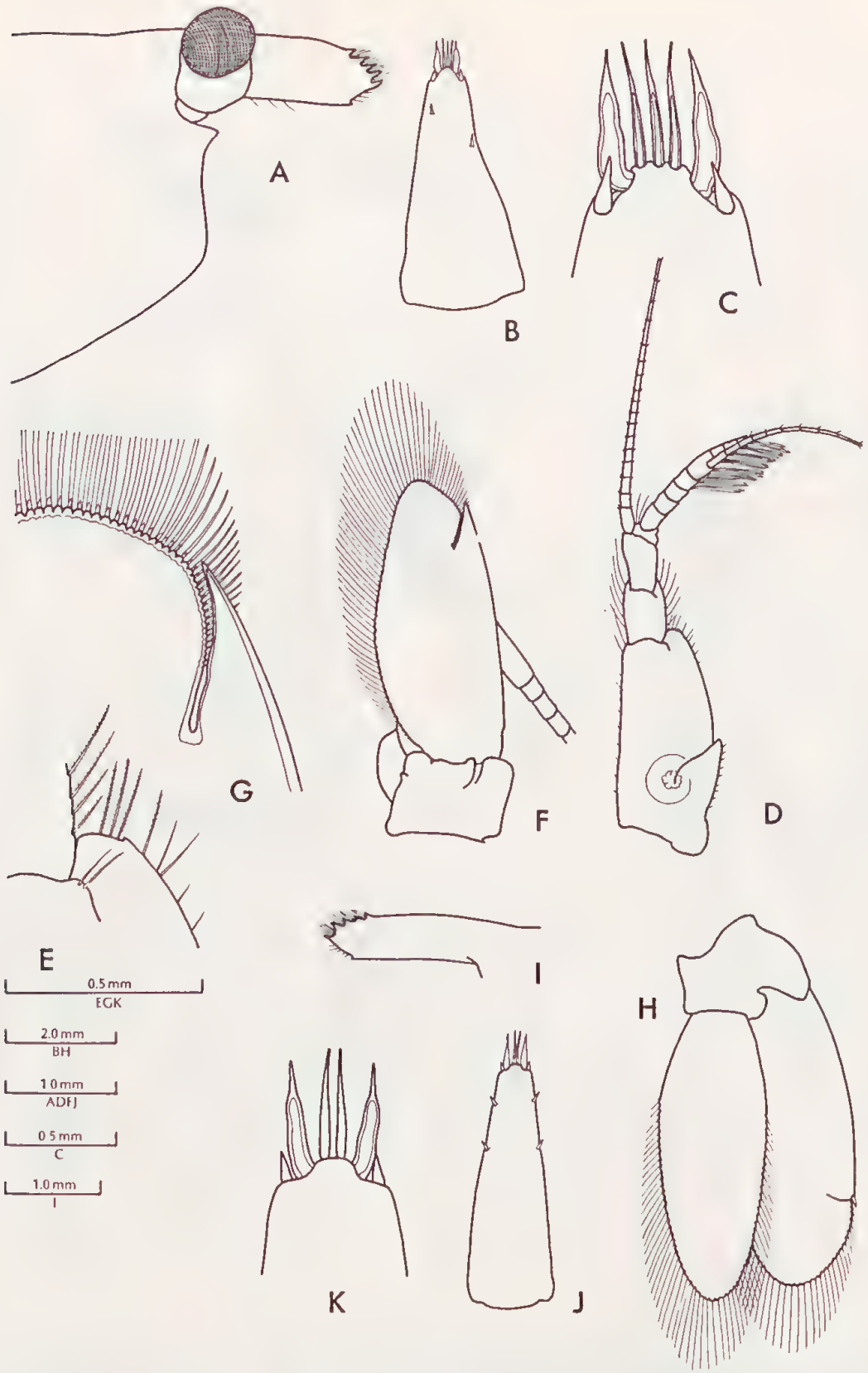

Fig. 7. *Anchistus australis* sp. nov., forma *typica*, female. A, anterior region of carapace. B, telson (abnormal). C, tip of telson. D, antennule. E, disto-lateral angle of proximal segment of antennular peduncle. F, antenna. G, disto-lateral spine of scaphocerite. H, uropod. Male: I, rostrum. J, telson (normal). K, tip of telson.

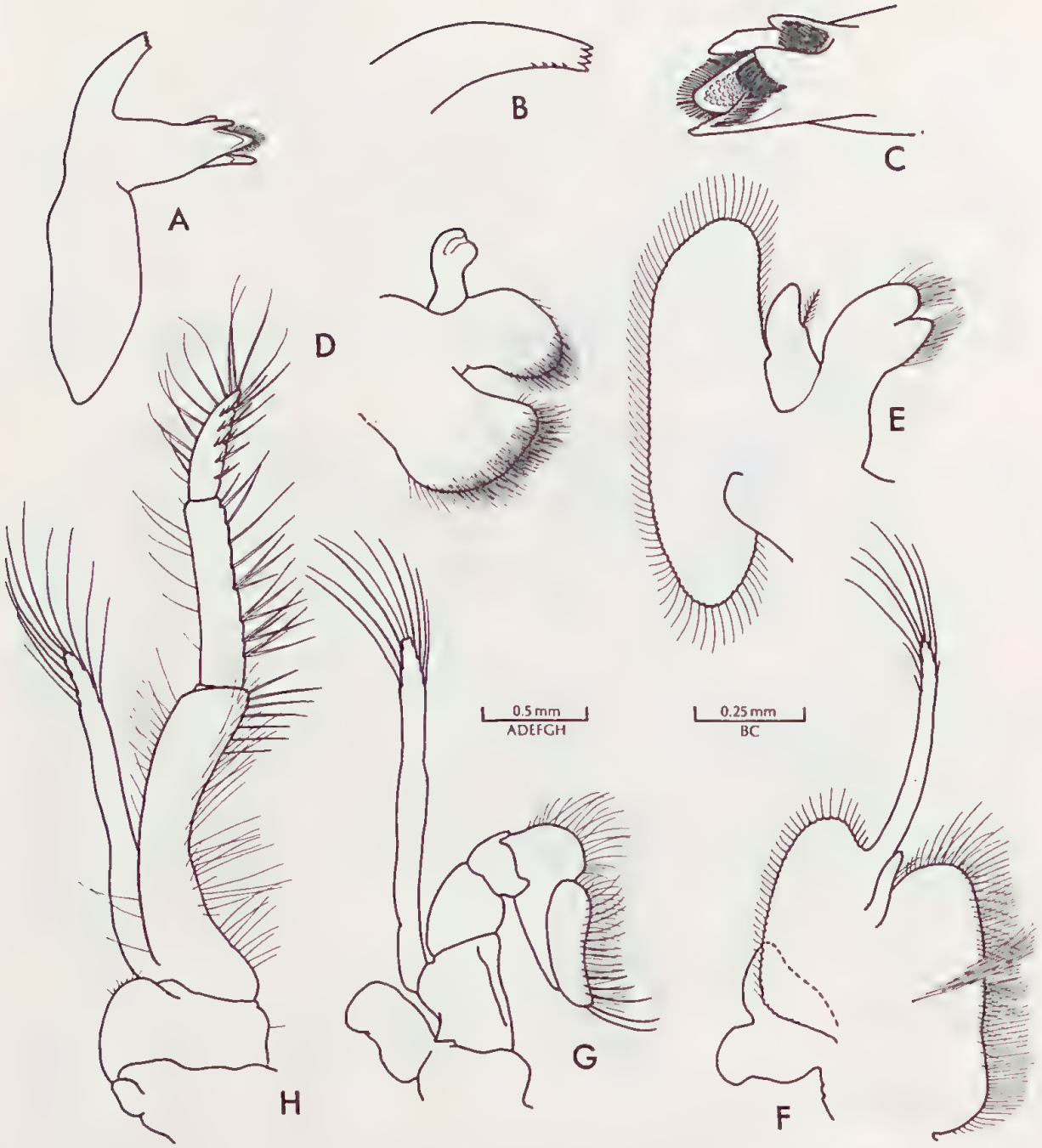

Fig. 8. *Anchistus australis* sp. nov., forma *typica*, female. A, mandible. B, incisor process. C, molar process. D, maxillula. E, maxilla. F, first maxilliped. G, second maxilliped. H, third maxilliped.

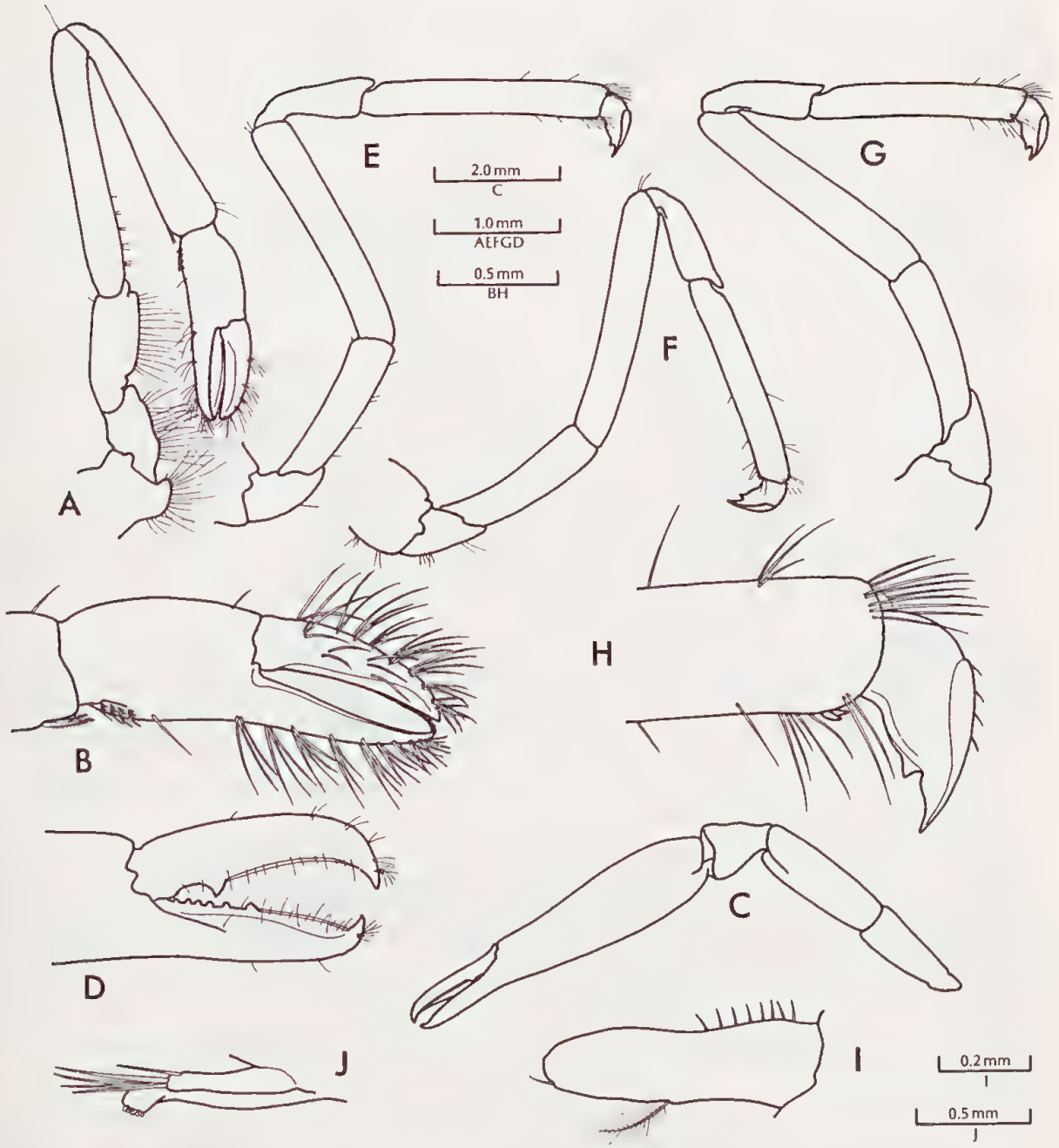

Fig. 9. *Anchistus australis* sp. nov., forma *typica*, female. A, first pereiopod. B, chela of first pereiopod. C, second pereiopod. D, fingers of chela of second pereiopod. E, third pereiopod. F, fourth pereiopod. G, fifth pereiopod. H, dactylus of fifth pereiopod. Male: I, endopod of first pleopod. J, appendix masculina and appendix interna.

The third abdominal segment is not produced posteriorly in the dorsal midline. The pleura of the abdominal segments are rounded. The sixth segment is 1.25 times longer than deep, with blunt postero-lateral and postero-ventral angles, and one and a half times longer than the fifth segment. The telson is about one and a half times longer than the sixth segment, tapering, about twice as long as its basal width in females and three times as long in males. The lateral margins are straight or feebly convex. There are two pairs of well developed dorsal spines situated sub-marginally at three and four fifths of the telson length. Three pairs of terminal spines are present. The lateral pair are slightly smaller than the dorsal spines. The intermediate spines are swollen for the proximal three quarters of their lengths and are about three times longer than the lateral spines. The submedian spines are sparsely setose, slender and slightly exceed the intermediate spines.

The eyes are well developed but small. The cornea is hemispherical and lies transversely upon the slightly wider eyestalk. A small accessory pigment spot is present dorsally. The eyestalk is subcylindrical, slightly expanded, flat, compressed proximally, about 1.3 times longer than the corneal diameter.

The basal segment of the antennular peduncle is twice as long as wide. The antero-lateral angle is produced, rounded, and bears a minute tooth. The lateral border is gently convex. The stylocerite is broad and blunt and is less than half the length of the segment. The intermediate and distal segments are subequal, equal to about three fifths of the length of the basal segment. The lateral border of the intermediate segment is produced to form a setose lobe. The lower flagellum if filiform, subequal to the peduncle and has seventeen segments in the dissected specimen. The upper flagellum is biramous with the two rami fused for the five proximal segments. The shorter ramus consists of three free segments and bears eight groups of aesthetascs. The longer ramus consists of nine free segments.

The basicerite of the antenna is unarmed laterally. The carpocerite extends to the middle of the lateral border of the scaphocerite. The antennal flagellum is well developed, slightly exceeding the telson. The scaphocerite is about 2.3 times longer than wide and far exceeds the antennular peduncle. The lateral border is distinctly convex and bears a large acute disto-lateral tooth. The lamina extends well beyond the antero-lateral tooth and is bluntly angled distally. The proximal part of the lateral margin of the lamina is inflected along the side of the antero-lateral tooth.

The mandible is without a palp. The incisor process is feebly developed and bears four small subequal teeth distally. Four small denticles are present on the distal part of the medial border. The molar process is robust and bears several stout processes and brushes and patches of setae. The maxillula has the upper lacinia short and broad, bluntly rounded with numerous simple setae. The lower lacinia is even broader and densely fringed with numerous setae. The palp is feebly bifid and without a seta. The maxilla bears a stout palp with a single short plumose seta in the middle of the medial border. A single large, broad bifid endite is present with slender simple setae distally on each lobe. The scaphognathite is well developed and narrow. The first maxilliped shows no separation into basal and coxal portions, the medial border being fringed with long slender setae. The palp is subcylindrical with two setae on the medial border. The exopod is well developed with a large caridean lobe. A bilobed epipod is also present. The second maxilliped shows no special features. A well developed exopod is present with a subrectangular epipod. The third maxilliped is slender. The terminal segment is about three fifths of the length of the penultimate segment. The anti-penultimate segment is not expanded and is subequal to the penultimate and terminal segment combined. The exopod is well developed and exceeds the length of the antipenultimate segment. A large, stout, rounded epipod is present and also a rudimentary arthrobranch. The medial borders of the segments of the endopod are sparsely setose with long slender plumose setae.

The first pereiopod is slender and exceeds the scaphocerite by the length of the chela and one third of the carpus. The chela is robust with the fingers subequal to the palm. The

fingers are spatulate, with finely pectinate cutting edges laterally and entire edges medially, and numerous tufts of long setae. The carpus is slender, slightly expanded distally and 1.4 times the length of the chela. The merus is twice the length of the ischium and 1.1 times the length of the carpus. The basis is slightly shorter than the ischium and the coxa bears a large rounded medial lobe. The medial borders of ischium, basis and the coxal process bear fringes of long setae. The second pereiopods are small, subequal and similar in the female. In the male they are markedly unequal, one being quite robust. The major second pereiopod has a subcylindrical palm tapering distally, slightly more than twice the length of the dactylus. The dactylus is strongly hooked distally and distinctly exceeds the fixed finger. A single large acute triangular tooth is present on the proximal half of the cutting edge. The fixed finger bears 4-5 small teeth opposite the tooth on the dactylus, which opposes into a pit on the fixed finger, and a small acute tooth anterior at the middle of the cutting edge. The distal halves of the cutting edges are entire. The carpus is small and stout, triquetral, about one quarter of the length of the palm, and unarmed. The merus is robust, two and a quarter times longer than wide, and unarmed. The ischium is two thirds of the length of the merus and unarmed. The minor second pereiopod and the chelae of the females are generally similar, smaller in size and less robust, with weaker teeth, than in the male major second pereiopod. The ambulatory pereiopods are moderately robust and generally similar. The fifth pereiopod reaches anteriorly to the end of the carpocerite. The dactylus is short and stout, with the dorsal aspect flattened and minutely imbricate. The posterior margin bears a small acute tooth. The prododus is about four times the length of the dactylus with numerous simple setae distally. The disto-ventral ends of the fourth and fifth pereiopods are armed with a pair of short stout spines that are absent from the third pereiopod. The carpus is half the length of the propodus and the merus, which is subequal to the propodus. The ischium is two thirds of the length of the merus. The propodus of third, fourth and fifth pereiopods have lengths in the ratio of 55 : 49 : 48 and the meri 57 : 57 : 59. The sternites of the second and third thoracic segments are broad and unarmed. The sternite of the fourth thoracic segment bears a broad transverse lamina with a distinct median notch. The fifth sternite bears a broad lamina, with a small median notch, posteriorly to the coxae of the second pereiopods.

The pleopods show no special features. The endopod of the first male pleopod bears a single plumose seta in the middle of its lateral border. The distal border is rounded with a single small simple seta. The medial border is straight, with about eight short simple setae along the proximal half. The appendix masculina is short, exceeded by the appendix interna, with four long, robust, simple setae distally with a single subterminal seta on the lateral border. The uropods exceed the tip of the telson by one third of the telson length. The basipodite has a bluntly rounded postero-lateral angle. The lateral border of the exopod is feebly convex, with a small mobile spinule distally.

The ova are numerous and small. In a dissected female, carapace length 4.5 mms, 312 ova were being carried, greater diameter 0.48 mms.

TYPES: The types are deposited in the collections of the Australian Museum. The male from Capre Cay is selected as the holotype, registration number P17520.

HOST: *Tridacna whitleyi* Iredale (Lamellibranchia : Tridacnidae).

DISTRIBUTION: Type locality, Capre Cay, Swain's Reef.

REMARKS: *Anchistus australis* is most closely related to *Anchistus miersi* (De Man) and especially *A. demani* Kemp. It may be readily distinguished from the former by the absence of an antennal spine and from the latter by the acute and non-truncate anterior tip to the rostrum. The accessory spine on the dactyl of the ambulatory pereiopods is much larger than in *A. demani* and the dorsal surface less strongly imbricate. The accessory spine is also less acute than in *A. miersi* and the dorsal surface of the dactylus is not hollowed to form a scoop. In *A. demani,* in addition, the antero-lateral margin of basal antennular segment is

unarmed, the fingers of the first pereiopods are not pectinate and spatulate and the anterior pair of dorsal telson spines are situated at the middle of the telson length in contrast to *A. australis*. *A. australis* is a distinctly larger species than *A. demani*, in which Kemp states that the ovigerous females are about 10 mm. in length, *A. australis* having ovigerous females of 20 mms. and larger.

14. **Anchistus australis** sp. nov., forma **dendricauda** (Fig. 10)

MATERIAL EXAMINED: 1 ovig. ♀, CL. 6.0 mm, West Cay, Diamond Islets, 21 October 1964.

DESCRIPTION: Generally similar to *A. australis* forma *typica*, but with the dorsal margin of the rostrum bearing a series of eight slender acute teeth. The ventral margin bears a single small tooth. The intermediate posterior terminal spines of the telson terminate in a series of short blunt processes.

HOST: *Tridacna squamosa* Lam. (Lamellibranchia : Tridacnidae).

REMARKS: The exact status of this single specimen cannot be fully ascertained. All the specimens of *A. australis* obtained from *T. whitleyi* have four or five dorsal rostral teeth only and all lack the dendritic termination of the intermediate posterior telson spines. These spines however, may be of pathological origin. The present specimen is also large and associated with a different host. The examination of further specimens from known hosts is necessary to establish the exact relationships between the two taxa.

15. **Philarius gerlachei** (Nobili) (Fig. 11.)

Restricted synonymy:

Harpilius gerlachei Nobili, 1905: 160; 1906: 45, pl. 4. Kemp, 1922: 229 (key), 238-239, figs. 74-75.

Philarius gerlachei — Holthuis, 1952: 15, 152-153, fig. 69. Patton, 1966: 276, 288 tab. 1, 290 tab. 2. Bruce, 1972: 406-407, 413 (key).

MATERIAL EXAMINED: 1♂, CL. 3.3 mm, West Cay, Diamond Islets, 23 October 1964. 1♀, CL. 3.5 mm, One Tree Island, Capricorn Group, no date.

HABITAT/HOST: No data.

DISTRIBUTION: Type locality, off Arzana Island, Persian Gulf. Also recorded from the Red Sea, to Madagascar as far east as the Gilbert Islands and Samoa. Previously recorded from Australia by Patton (1966) at Willis Island, Bet Reef, Restoration Rock, Heron Island and Wistari Reef.

REMARKS: This species is normally associated with corals of the genus *Acropora* (Patton, 1966; Bruce, 1972).

The male specimen has a rostrum which slightly exceeds the length of the antennular peduncle and is armed with four dorsal and one large ventral tooth. There are no teeth posteriorly to the orbital margin. In the female there are five dorsal rostral teeth, the most posterior tooth over the anterior margin of the carapace. The orbital margins are very well marked. The first pereiopods are missing in the male but present in the female. They are slender and exceed the scaphocerite, which bears a very strong disto-lateral spine, by two thirds of the length of the carpus. The chela is robust with stout fingers, slightly shorter than the palm in length and densely covered with short setae. The second pereiopods are present in both specimens. The fingers are more slender in the male and armed with six small teeth whereas in the female five larger teeth are present upon each finger. The carpus is without a disto-lateral spine. The dactyli of the ambulatory pereiopods are strongly compressed as well as being strongly hooked. They are surrounded by a dense brush of fine setae arising from the distal end of the propodus. A small triangular tooth is present medially

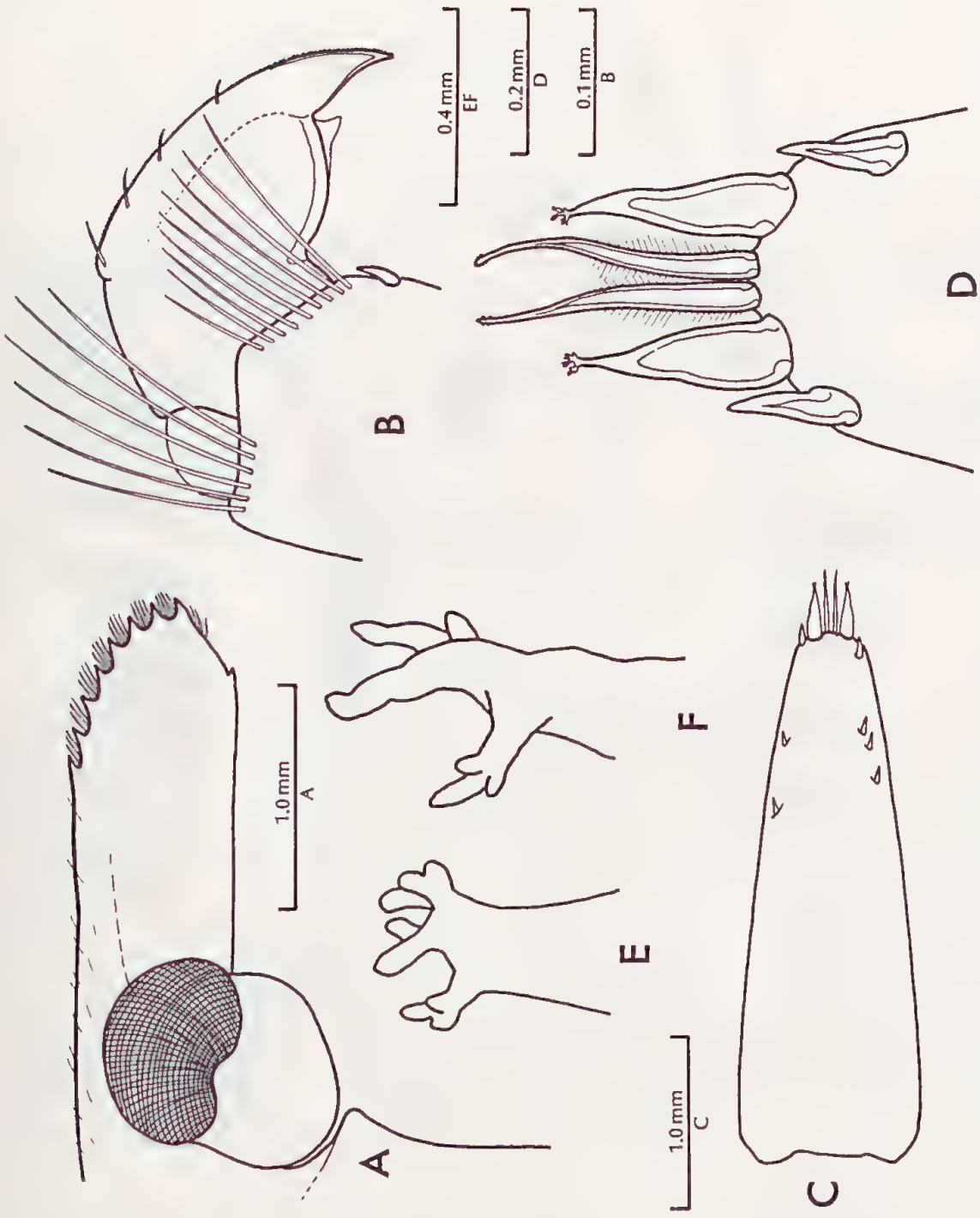

Fig. 10. *Anchistus australis* sp. nov., forma *dendricauda*, female. A, rostrum and orbital region. B, dactylus of ambulatory pereiopod. C, telson. D, tip of telson. E, tips of intermediate posterior telson spines.

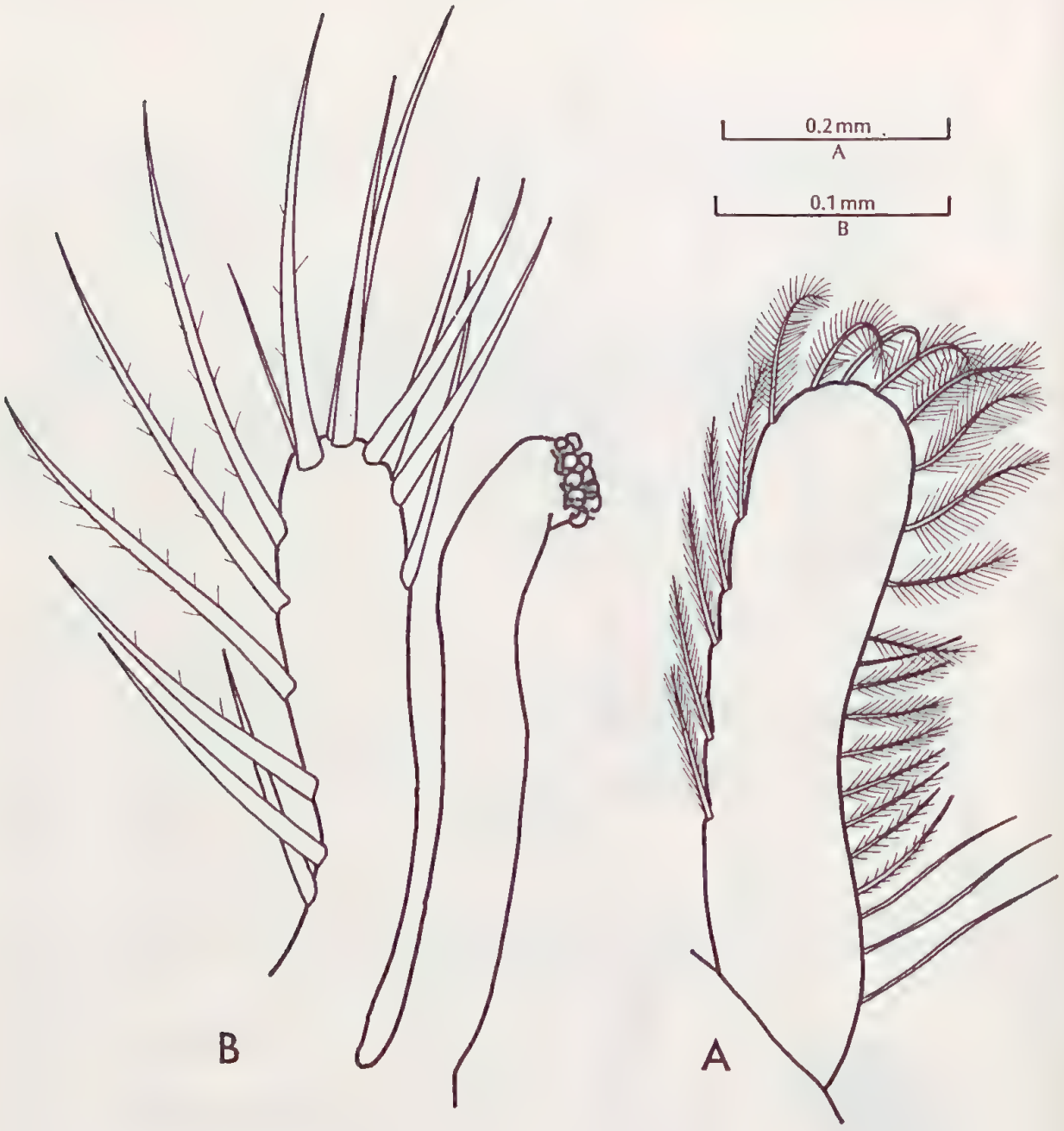

Fig. 11. *Philarius gerlachei* (Nobili), male. A, endopod of first pleopod. B, appendix masculina and appendix interna.

on the fourth thoracic segment. This tooth is relatively smaller and less conspicuous than the tooth present in this position in the syntypes held in the Museum National d'Histoire Naturelle, Paris. A similar process is also present in *P. imperialis* Kubo. The first male pleopod and appendix masculina have not been previously described and are now illustrated.

16. **Ischnopontonia lophos** (Barnard)

Restricted synonymy:

Philarius lophos Barnard, 1962: 242-243, fig. 2.

Ischnopontonia lophos — Bruce, 1966: 585-595, figs. 1-5; 1971: 19-20.

MATERIAL EXAMINED: 2♀ (1 ovig.), CL. 1.6, 1.6 mm, One Tree Island, Capricorn Group, no data.

HOST: *Galaxea fascicularis* (L.) (Scleractinea: Oculinidae).

DISTRIBUTION: Type locality, Inhaca Island, Mocambique. Also recorded from Kenya, Tanzania, Zanzibar, Madagascar, Comoro and Seychelle Islands, Singapore and Pulau Perhentian Besar. Previously recorded in Australian waters from Great Palm, Orpheus and Fantôme Islands, Townsville.

REMARKS: Both specimens agree well with the previous descriptions. Each specimen has ten dorsal rostral teeth. The only noteworthy difference is that the ovigerous female is particularly small, CL. 1.6 mm, in comparison with the Townsville specimens, CL. 2.1-2.5 mm. The ova are few in number, greatest length 0.5 mm.

17. **Harpiliopsis depressa** (Stimpson) (Fig. 12 a-c).

Restricted synonymy:

Harpilius depressus Stimpson, 1860: 38. Kemp, 1922: 228 (key), 231-234, fig. 69-70.

Harpiliopsis depressus — Borradaile, 1917: 324, 380, pl. 56 fig. 22. Holthuis, 1951: 70-75, pl. 21, 22 a-f; 1952: 16, 182-184, fig. 90. Patton, 1966: 277, 288 tab. 1, 290 tab. 2, 291 tab. 3.

MATERIAL EXAMINED: 4♂, 5♀ (4 ovig. ♀), West Cay, Diamond Islets, 23 October 1964.

MEASUREMENTS: CL. males, 2.3-2.7 mm: females 2.4-2.5 mm; ovigerous females 3.0-3.4 mm.

HOST: Not recorded, coral-head washings.

DISTRIBUTION: Type locality, Hawaii. Widespread and common in the Indo-West Pacific region; from the Red Sea to Mocambique and Madagascar as far as Hawaii, and also extending to the Galapagos Islands and the tropical west coast of America. Previously recorded by Patton (1966) from Australian waters: Willis Island, Restoration Rock, Heron Island and Wistari Reef.

REMARKS: The specimens agree with the descrintion given by Kemp (1922). The number of rostral teeth varies as follows: — males $\frac{6}{5}$, $\frac{7}{5}$, $\frac{7}{7}$, $\frac{7}{7}$; non-ovigerous females $\frac{5}{7}$, $\frac{6}{7}$; ovigerous females $\frac{4}{5}$, $\frac{4}{4}$, $\frac{6}{4}$. Where there are more than five dorsal teeth, the additional teeth lie on the posterior third of the rostral lamina and are distinctly smaller and more slender than the robust anterior dorsal and ventral teeth. There is a transverse ridge across the fourth thoracic sternite. The pleura of the fourth and fifth abdominal segments are both pointed. The position of the dorsal telson spines is slightly variable. In most examples the posterior pair of spines lies halfway between the anterior pair, which is situated at the

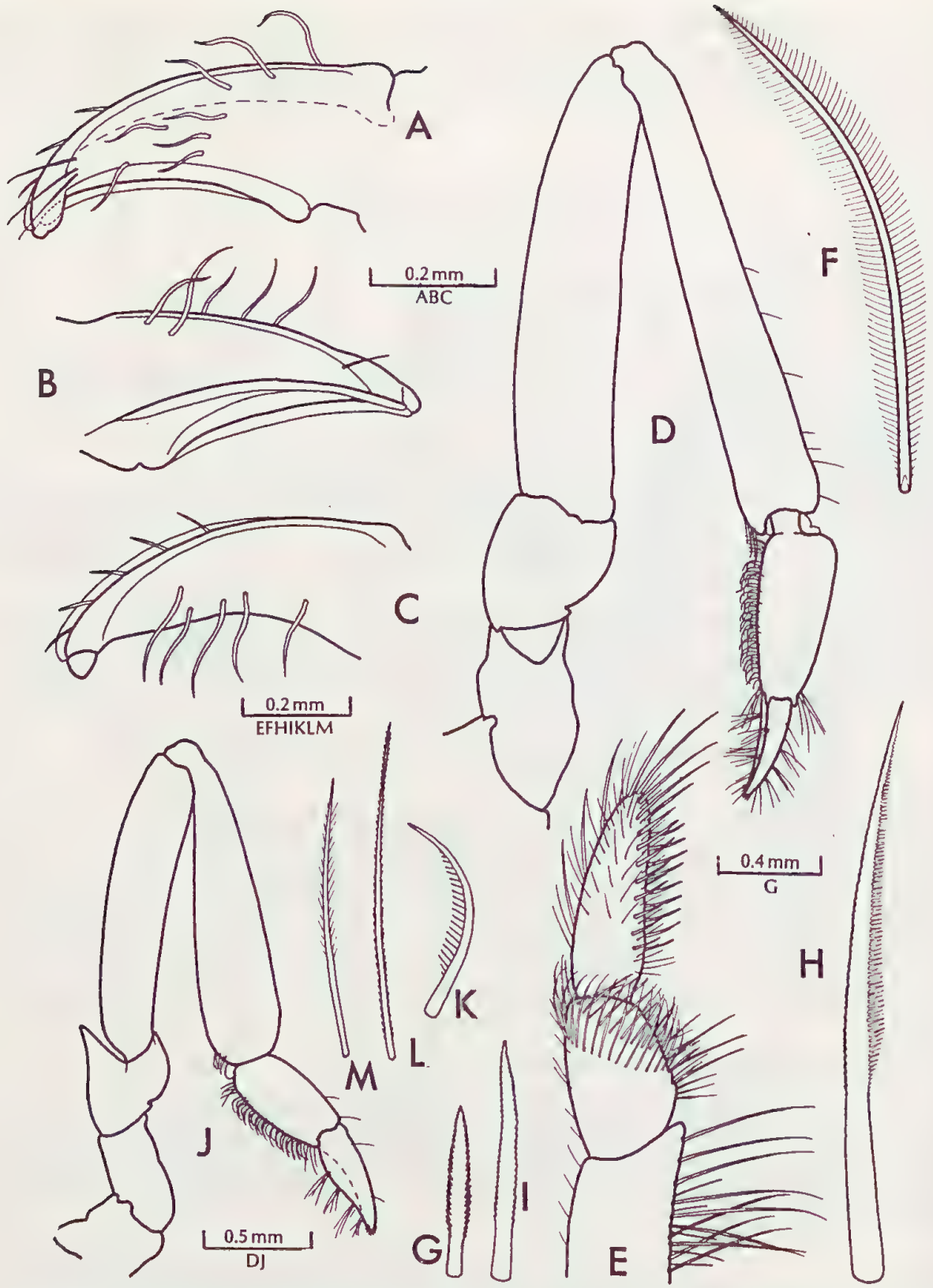

Fig. 12. *Harpiliopsis depressa* (Stimpson). Dactylus of ? fifth pereiopod. A, lateral. B, dorsal. C, dorsolateral oblique. *Coralliocaris superba* (Dana). D, first pereiopod. *Coralliocaris viridis* Bruce. E, distal portion of endopod of third maxilliped, dorsal aspect. F, seta from antepenultimate segment. G, from inner margin of terminal segment. H, from tip of terminal segment. I, seta from second maxilliped, terminal segment. *Coralliocaris venusta* Kemp. J, first pereiopod. K. seta from ventral aspect of palm. L, M, setae from fingers.

middle of the telson length, and the posterior margin, but in some specimens they lie closer to the anterior pair. Most of the second pereiopods have been preserved, although detached, but none have the slender characteristic of *H. spinigera* (Ortmann).

The dactylis of the ambulatory pereiopods are stout, hooked and twisted. In the present collection they are rather blunt and with a pair of longitudinal carinae. One carina extends along the ventral margin of the dactyl and the other along the dorso-lateral aspect. Both carinae are bluntly rounded distally. A series of short, strong setae lie along the margin of the dorsal carina and a number of longer setae arise from the lateral aspect of the dactylus. The lateral aspect of the dactylus is strongly convex and the medial aspect is flattened.

This species is one of the best known coral commensal shrimps and is one of the few of the Indo-West Pacific species of the Pontoniinae that are also found in the Eastern Pacific region. Patton (1966) found his Barrier Reef specimens of this species in association with corals of the genera *Pocillopora, Stylophora* and *Seriatopora*. There have been no records from the rest of Australia.

18. **Coralliocaris superba** (Dana) (Figs. 12d).

Restricted synonymy:

Oedipus superba Dana, 1852: 25; 1852a: 573; 1855, pl. 37.

Coralliocaris superba — Stimpson, 1860: 38. Holthuis, 1952: 17, 189-191, fig. 91. Patton, 1966: 277, 288 tab. 1, 290 tab. 2. 292 tab. 4.

MATERIAL EXAMINED: 1♀, CL. 3.6 mm, Stn. 1, Swain's Reef, 1962.

HOST: Not recorded.

DISTRIBUTION: Type locality Tongatabu, Tonga Islands. Widespread and common throughout the Indo-West Pacific region from the Red Sea to Mocambique east to the Society Islands but absent from Hawaii. Previously recorded from Australian waters by Patton (1966) from Willis Island, Restoration Rock, Heron Island, Wistari Reef and Moreton Bay.

REMARKS: The single example, which is non-ovigerous and slightly macerated, has five dorsal and two ventral rostral teeth and shows no significant differences from the descriptions given by Kemp and Kubo. There is no median process on the fourth thoracic sternite. The whole of the ventral aspect of the palm of the chela of the first pereiopods is provided with large numbers of short, curved setae which bear numerous perpendicular robust setules along the proximal two thirds of the anterior border. Groups of longer and more slender setae bearing rows of minute setules along anterior and posterior borders arise from the median aspect of the palm and the bases of the fingers. The fingers are distinctly shorter than the palm, slender and compressed, with the edges situated centrally.

19. **Coralliocaris venusta** Kemp (Figs. 12 j-m)

Restricted synonymy:

Coralliocaris venusta Kemp, 1922: 274-276, figs. 100-101, Holthuis, 1952: 17, 191-192, fig. 93. Patton, 1966: 277, 288 tab. 1.

MATERIAL EXAMINED: 1♀, CL. 2.3 mm, One Tree Island, Capricorn Group, no date.

HOST: Not recorded.

DISTRIBUTION: Type locality, Tholayiram Paar, Gulf of Manaar. Also known from Zanzibar, Kenya, Tanzania, Madagascar, the Seychelle Islands, Indonesia and Samoa. Previously recorded by Patton (1966) from Willis Island, Restoration Rock and Heron Island.

REMARKS: The single example agrees well with the original description. The rostrum bears only a single dorsal rostral tooth and no ventral teeth. The first pereiopod is more robust than in *C. graminea* and *C. superba*. The mero-ischial joint is highly mobile and the disto-lateral angle of the ischium is produced in the form of an acute triangular process. The basis and coxa are non-setose. The palm of the chela is provided with a dense brush of serrated, hooked setae as in the two preceeding species. The fingers are distinctly longer than in those species being almost subequal to the palm. The fingers are more robust and hollowed with the cutting edges situated along the lateral aspects. The cutting edges are entire and the dorsal edge of the dactylus is sharply carinate. The fixed finger is provided with numerous dense tufts of long minutely serrate setae. The sternite of the fourth thoracic segment is unarmed. This species is an obligate commensal of *Acropora* corals.

20. **Coralliocaris viridis** Bruce (Figs. 12 e-i)

Coralliocaris viridis Bruce, 1974: 222-224, fig. 1 a-b; 1974: 260 fig. 1, 262-263.

MATERIAL EXAMINED: 1♂, 1 ovig. ♀, CL. 2.4, 3.1 mm, One Tree Island, Capricorn Group, December 1966.

HOST: *Acropora* sp. (Scleractinea: Acroporidae).

DISTRIBUTION: Type locality, Mombasa, Kenya. Also known from Zanzibar and Madagascar. Not previously recorded from Australia.

REMARKS: Both specimens have four dorsal and one ventral rostral teeth. The dactyli of the ambulatory pereiopods appear very similar to those of *J. japonica* (vide infra) but with simple instead of scalloped margins. The sternite of the fourth thoracic segment is unarmed. The distal half of the dorsal surface of the penultimate segment of the third maxilliped bears a double row of long finely plumose setae which curve distally to enclose a basket-like space. The distal segment bears numerous long, stout dentate setae. The antepenultimate segment is provided with long slender simple setae along its medial border. The first pereiopod is very similar to that of *C. superba* (vide supra) except that the carpus is distinctly longer than the merus. The chelae of the second pereiopods are subequal in the male but the right is distinctly larger than the left in the female. The ova are numerous, over 170, and 0.45 mm. in greatest diameter.

Patton (1966) reported numerous examples of the closely related *C. graminea* (Dana) from a number of localities off the Queensland coast, and it is possible that some of these should be referred to *C. viridis*, which was not recognized at that time. He notes that the colour pattern of his material is longitudinally striate, as is normally found in *C. graminea*. *C. viridis*, like *C. graminea* is an obligate associate of *Acropora* corals.

21. **Jocaste japonica** (Ortmann) (Fig. 13 d-e, g-h)

Restricted synonymy:

Coralliocaris superba var. *japonica*. Ortmann, 1890: 509, pl. 36 Fig. 22.

Jocaste lucina (partim) — Holthuis, 1952: 17, 193-195, Fig. 94.

Jocaste japonica — Patton, 1966: 279-280, 288 tab. 1, 390 tab. 2, Fig. 3b. Bruce, 1969: 298-300, Fig. 1.

MATERIAL EXAMINED: 1♂, CL. 2.7 mm, Swain's Reef, 1962. 1 ovig. ♀, CL. 2.7 mm, West Cay, Diamond Islets, 23 October 1964.

HOST: Not recorded.

DISTRIBUTION: Type locality, Kagoshima, Japan. Recorded from Kenya, Tanzania, Madagascar, Comoro Islands, Seychelle Islands, and Maldive Islands and Mauritius in the

Indian Ocean; South China Sea, Indonesia, New Caledonia, Palau Islands and the Marshall Islands. Recorded from Australia by Patton (1966) from Restoration Rock, Willis Island, Heron Island and Wistari Reef. The reference in Bruce (1969) to the occurrence of this species at Bet Rock is erroneus.

REMARKS: The specimens correspond with Patton's redefinition of Ortmann's species. The male has four dorsal and two ventral rostral teeth and the female has four dorsal and one ventral rostral tooth. In both specimens the minor second pereiopod is missing. The first pereiopods are very similar to those of *J. lucina*. The major second pereiopod is more robust than in that species, and is about 3.3 times longer than broad. Dorso-ventral flattening of the palm is well marked and the disto-ventral meral spine has a convex distal margin. The carpus is unarmed. The dactylus of the ambulatory pereiopods bears a distinct and strongly hooked unguis. A large hoof-shaped basal process is present. The outer rim of this process is formed by a row of small slightly overlapping scalloped plates. The central cavity enclosed by the rim appears to be filled with a dense mass of fine closely packed setae. The fourth thoracic sternite is broad and unarmed. The endopod of the male first pleopod is less expanded distally than in *J. lucina*. The proximal half of the medial border bears seven fine setae. The distal half is armed by three curved spines. The other margins are devoid of setae. On the second pleopod, the appendix masculina is greatly exceeded by the appendix masculina which bears about 8-10 concinni distally. The appendix masculina bears a single large, slightly curved, robust, strongly spinulate spine and a smaller straight simple spine distally. The median border bears a single spinulate spine subterminally and the lateral border bears a row of four spines distally. The proximal spine is feeble, the adjacent spine is simple and the longest and the two remaining spines bear a few setules only. The ova are numerous, 125 being present and have a major diameter of 0.57 mms.

22. **Jocaste lucina** (Nobili) (Fig. 13 a-c, f, i.)

Restricted synonymy:

Coralliocaris lucina Nobili, 1901: 5; 1906: 57.

Jocaste lucina (partim) — Holthuis, 1952: 17, 193-195, fig. 94

Jocaste lucina — Patton, 1966: 278-279, 288 tab; 1, 290 tab. 2, Fig. 2a. Bruce, 1969: 298-307, Fig. 2.

MATERIAL EXAMINED: 1♂, 1 ovig. ♀, CL. 2.4, 2.8 mm. West Cay, Diamond Islets, 23 October, 1964.

HOST: Not recorded.

DISTRIBUTION: Type locality, Eritrea. Widespread and common throughout most of the Indo-West Pacific region excluding Hawaii and Japan, from the Gulf of Aquaba to Madagascar to Johnson Island and Tahiti. Previously recorded from Australia by Patton (1966) from Restoration Rock, Wistari Reef, Willis Island, Heron Island and Moreton Bay. The reference in Bruce (1969) to the occurrence of this species at Bet Reef is erroneus.

REMARKS: The specimens agree exactly with the redefinition as given by Patton. The male has six dorsal and three ventral rostral teeth and the female has five and two respectively. The first pereiopods are long and slender. The chela is slender and bilaterally compressed. The fingers are tapering, about half the length of the palm, and with entire cutting edges which gape proximally. The fingers bear some tufts of short serrated setae which are curved backwards towards the palm. There are no rows of setae along the margins of the palm. The major chela of the second pair of pereiopods is comparatively slender, about 4.3 times longer than the greatest width of the palm, which is markedly dorso-ventrally flattened. The disto-ventral spine of the merus has a concave anterior margin. The carpus is unarmed. The dactyls of the ambulatory pereiopods are very similar to those of *J. japonica* (vide supra). The fourth thoracic sternite is broad and unarmed.

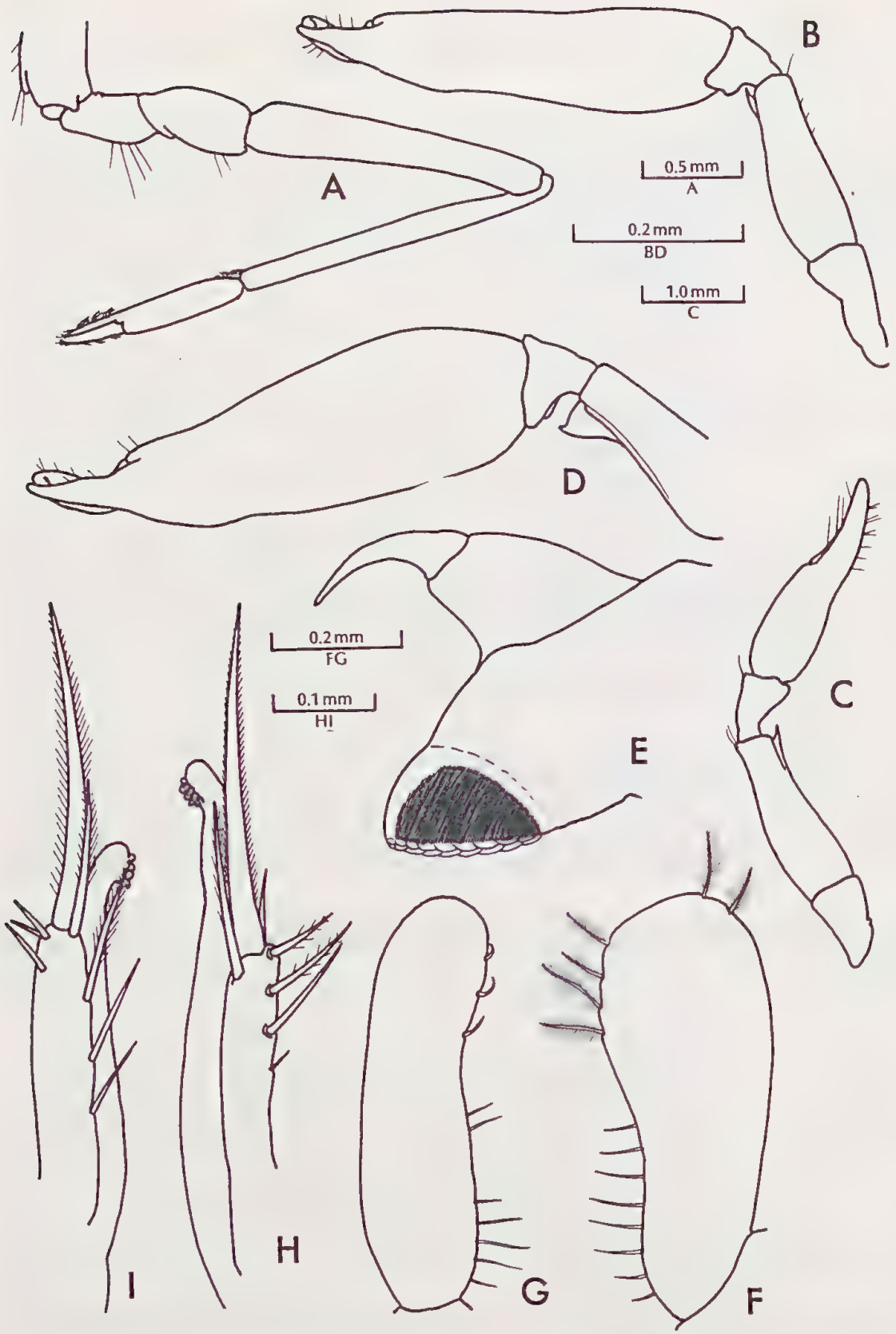

Fig. 13. *Jocaste lucina* (Nobili). A, first pereiopod. B, major second pereiopod. C, minor second pereiopod. F, endopod of male first pleopod. I, appendix masculina and appendix interna. *Jocaste japonica* (Ortmann). D, major second pereiopod. E, dactylus of ambulatory pereiopod. G, endopod of male first pleopod. H, appendix interna and appendix masculina.

The endopodite of the male first pleopod is expanded distally and bears a row of eight slender spines along the proximal half of the feebly concave medial border. The distal part of the medial border bears a row of four feebly plumose setae and a pair of densely plumose setae are situated subterminally on the lateral border. On the second pleopod the appendix interna, with four subterminal concinnuli, distinctly exceeds the appendix masculina. This process bears a single robust, slightly curved, strongly spinulate terminal spine. A row of four spines, which increase in length distally, arises from the medial border. The distal spine is markedly spinose and the penultimate spine is feebly spinulose. The distal end of the medial border bears three short simple spines.

The female carried 67 ova but a few had probably been lost. The major diameter of the ovum is about 0.43 mm.

This species is normally associated with corals of the genus *Acropora* and has been found on eleven different host species. The association of 23 specimens with two colonies of *Pocillopora verrucosa* (Ellis & Solander) at Willis Island is especially remarkable (Patton, 1966).

23. **Conchodytes tridacnae** Peters (Fig. 14 a-b)

Restricted synonymy:

Conchodytes tridacnae Peters, 1852: 288-289. Kemp, 1922: 280-285.

Pontonia tridacnae — McNeill, 1926: 300-301.

Conchodytes tridacnae (partim) — Holthuis, 1952: 17, 195-199, Fig. 95.

MATERIAL EXAMINED: 1 ovig. ♀, CL. 9.1 mm, West Cay, Diamond Islets, 23 October 1964. 1♂, 1 ovig. ♀, CL. 4.0, 4.8 mm, North East Cay, Herald Group, 12 November 1964. 1♂, 1 ovig. ♀, CL. 5.3, 7.6 mm, One Tree Island, Capricorn Group, December 1966.

HOSTS: *Tridacna squamosa* lam, *T. whitleyi* Iredale and *T. maxima* Roding (Lamellibranchia: Tridacnidae).

DISTRIBUTION: Type locality, Ibo, Mocambique. Distribution of this species is rather uncertain due to its frequent confusion with *C. meleagrinae*. Probably common and widespread throughout most of the Indo-West Pacific region. Specimens of *Conchodytes* associated with *Tridacna* spp. have been reported from Samoa (Dana, 1852), Ryu-Kyu Islands and Bonin Islands (Kubo, 1940) Maldive Islands (Borradaile, 1917), Laccadive Islands and Andaman Islands (Kemp, 1922), the Marshall Islands (Holthuis, 1953), also Palau Islands (Miyake & Fujino, 1968). The only record of this species from Australian waters is from the Torres Straits (Kemp, 1922).

REMARKS: The specimen reported as free living from North West Islet, Capricorn Group, by McNeill (1926) may possibly belong to *C. meleagrinae* as no host was recorded. The present specimens correspond well to the information given by Borradaile, Kemp and Kubo. In all specimens the carpus of the first pereiopod is distinctly longer than the merus. The fourth thoracic sternite is broad and unarmed. The fifth bears a low triangular ridge with a small median notch immediately posteriorly to the coxae of the second pereiopods.

The endopod of the male first pleopod is about six times longer than wide. A row of slender spines is present along the proximal part of the medial border. These spines, thirteen in number, increase slightly in length distally and are non-plumose. The distal part of the medial border bears five long spines and two plumose setae. Seven long plumose setae are present on the distal half of the lateral border and there are two plumose terminal setae. The appendix masculina exceeds the tip of the appendix interna. Its distal end is armed with eight long finely spinulate setae.

The ovigerous female bears numerous ova. A dissected example, carapace length 9.1 mms., bore 725 ova, with a greater diameter of 0.74 mms.

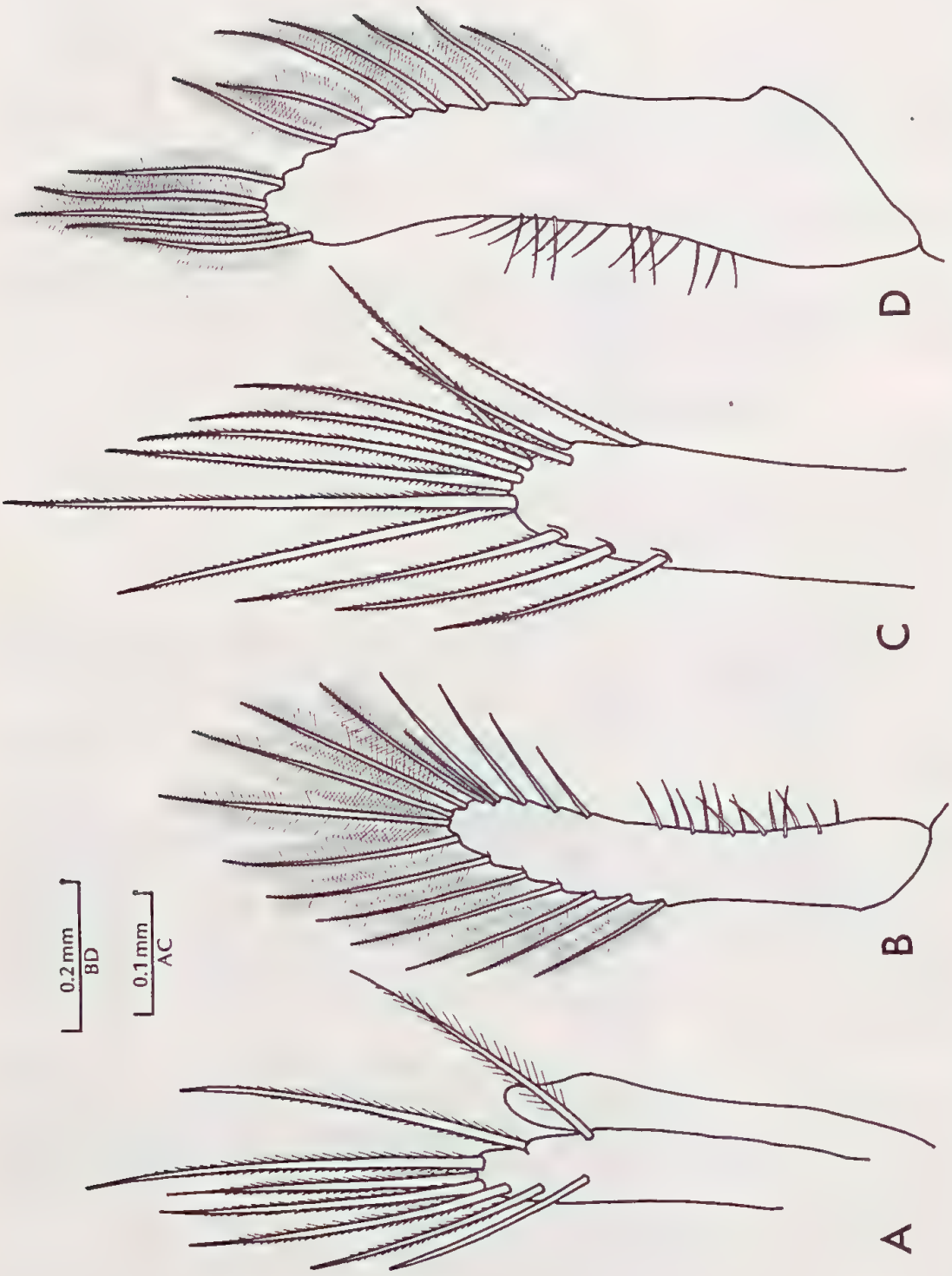

Fig. 14. *Conchodytes tridacnae* Peters. A, appendix masculina and appendix interna. B, endopod of male first pleopod. *Conchodytes meleagrina* Peters. C, appendix masculina. D, endopod of male first pleopod.

24. **Conchodytes meleagrinae** Peters (Fig. 14 c-d)

Restricted synonymy:

Conchodytes meleagrinae Peters, 1852: 289-290. Balss, 1921: 15.

?*Pontonia (Conchodytes) tridacnae* (partim). — Miers, 1884: 290.

Pontonia meleagrinae — Bate, 1888: 707, pl. 124 figs. 1-2. Thompson, 1901: 19.

Conchodytes tridacnae — McNeill, 1968: 7, 22.

MATERIAL EXAMINED: 4♂, 5♀ (4 ovig.), Gillett Cay, Swain's Reef, October 1962. 1 ovig. ♀, Heron Island, October 1962. 1♂, 1 ovig ♀, One Tree Island, Capricorn Group, November 1966.

MEASUREMENTS: CL. males, 4.0-5.7 mm; female 6.0 mm; ovigerous females 5.5-10.0 mm.

HOST: *Pinctada margaritifera* (L,) (Lamellibranchia: Pteriidae).

DISTRIBUTION: Type locality, Ibo, Mocambique. Also recorded from the Red Sea to Madagascar as far east as Hawaii. In Australia, reported from Warrior Reef (Miers, 1884), Torres Strait, (Bate, 1888; Kemp, 1922), N. W. Australia (Thompson, 1901), the Low Isles and Bat Reef (McNeill, 1968).

REMARKS: The specimens correspond well with published descriptions. In all cases the carpus of the first pereiopod was distinctly shorter than the merus and the relative lengths of these two segments appears to be the easiest way of distinguishing between these two species as the disto-lateral angle of the basal segment of the antennular peduncle is variable. The sternite of the fourth thoracic sternite is the same as in *C. tridacnae*.

In a dissected specimen the endopod of the male first pleopod bears a row of eighteen slender spines along the central portion of the medial border. The lateral border bears nine plumose setae, with two similar setae situated terminally and with a pair of plumose setae at the distal end of the medial border. The disto-medial border is without the slender non-plumose setae found in *C. tridacnae*. The appendix masculina is exceeded by the appendix interna. The extremity of the appendix is armed with four long slender finely serrated setae. Three similar setae are present on the medial border and five on the lateral border.

The ova are numerous, a dissected female, carapace length 10.0 mms, bore 479 eggs, with a greater diameter of 0.65 mms.

Pontonia tridacnae reported by McNeill (1926), from North West Islet, may possibly belong to this species. Its host was not recorded.

Incertae sedis

25. **?Araiopontonia** sp. (Fig. 15-16).

MATERIAL EXAMINED: 1 spm. damaged, CL. 1.5 mm, One Tree Island, Capricorn Group, 140 ft., 28 November 1966, coll. F. Talbot.

DESCRIPTION: Very small in size and slender, not depressed.

Carapace smooth. Rostrum well developed and acute, equal to the postocular carapace length, compressed distally. The dorsal margin is slightly elevated posteriorly and five dorsal teeth are present. These teeth are acute and directed anteriorly with their posterior margins parallel to the ventral margin of the rostrum. The interval between teeth decreases slightly towards the rostral tip. The ventral margin is straight, except at the tip, and lacks teeth. The midrib is well developed, expanded posteriorly and is convex immediately anteriorly to a pair of large blunt supra-ocular spines which form the superior part of the orbit. The inferior orbital angle is feebly produced and blunt. A well developed antennal spine is present on

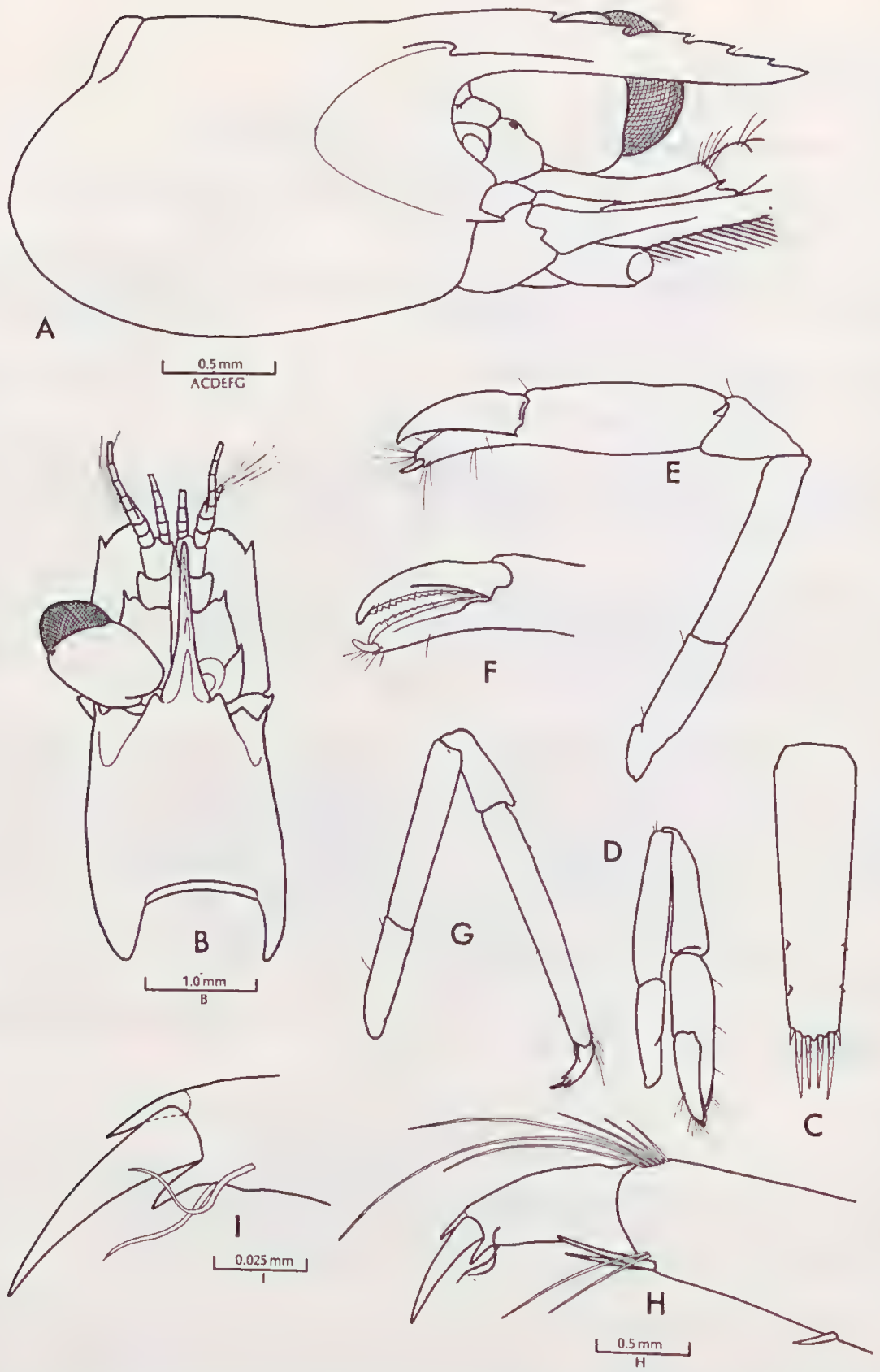

Fig. 15. *?Araiopontonia* sp. A, carapace and antennal region, lateral view. B, Carapace and antennae, dorsal view. C, telson. D, first pereiopod, E, second pereiopod. F, fingers of second pereiopod. G, third pereiopod (?). H, dactyous of (?) third pereiopod. I, tip of dactylus of (?) third pereiopod.

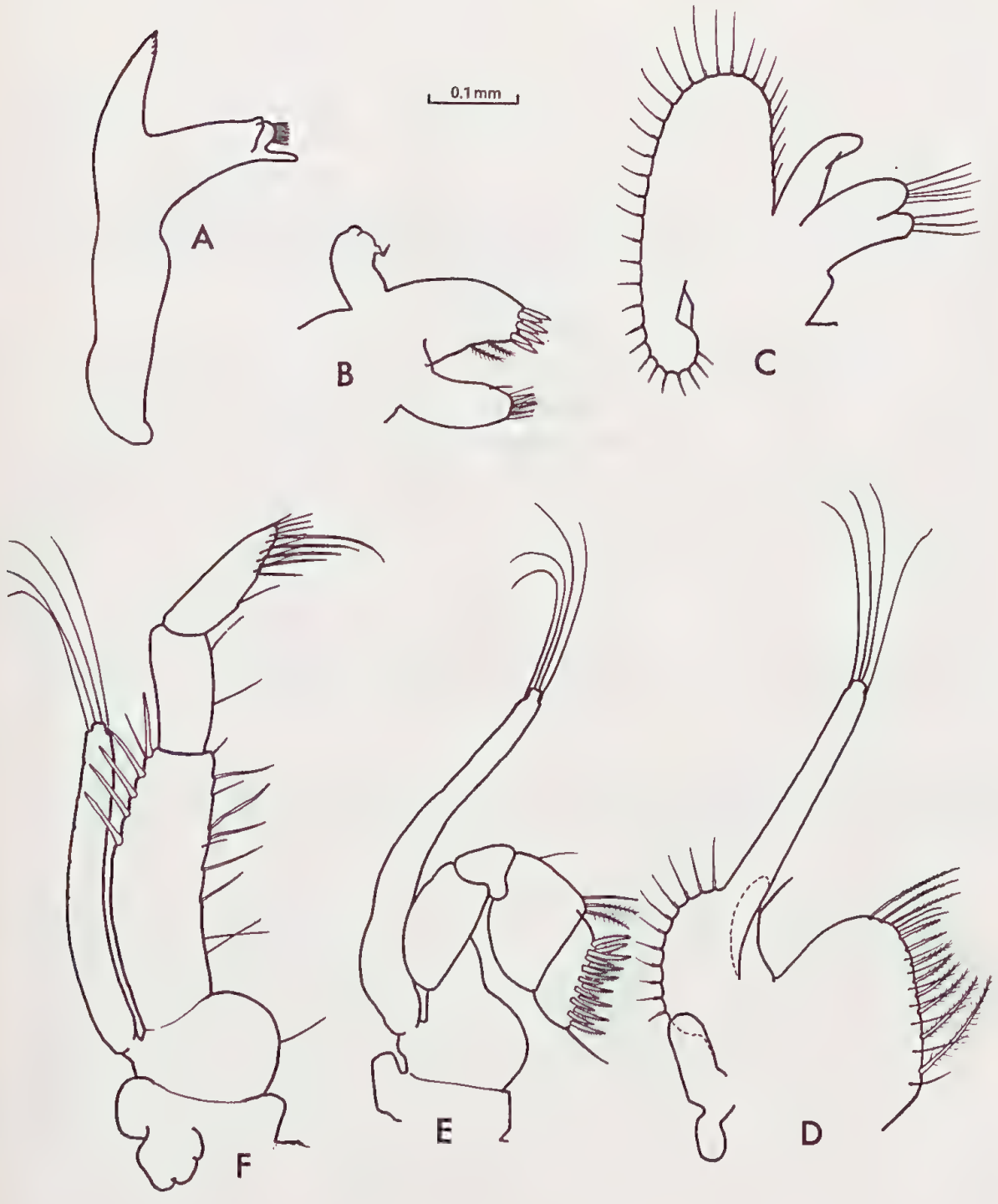

Fig. 16. *?Araiopontonia* sp. A, mandible. B, maxillula. C, maxilla. D, first maxilliped. E, second maxilliped. F, third maxilliped.

the anterior margin of the carapace at a level well below the inferior orbital angle, where it forms the antero-lateral margin of the orbit. The hepatic spine is absent. The antero-lateral angle of the carapace is obtusely rounded.

The abdomen is smooth and the third segment is not produced in the dorsal midline. The pleura of the first five segments are broadly rounded. The fifth segment is about half the length of the sixth segment and sub-equal to its depth. The posterior angle of the sixth segment is bluntly produced. The telson is narrow, straight sided, feebly tapering and slightly longer than the sixth abdominal segment. The distal margin is truncated. There are three pairs of terminal spines. The intermediate spines are long strong and slender, equal to slightly less than a quarter of the length of the telson. The submedian spines are also long and slender but are slightly shorter and less robust than the intermediate spines. The lateral spines are short and stout and equal to about one third of the length of the submedian spines. Two pairs of very small submarginal dorsal spines are present. The anterior pair is situated at two thirds of the telson length from the anterior margin and the posterior pair lies half way between the anterior pair and the posterior margin.

The antennular peduncle slightly exceeds the tip of the rostrum. The proximal segment is broad with an acute stylocerite reaching to the middle of its lateral border. The antero-lateral border is produced and bears a well developed tooth. A small lobe is present medially to the disto-lateral tooth. The intermediate and distal segments are short and stout, subequal in length and together equal about two thirds of the length of proximal segment. The disto-lateral border of the intermediate segment is slightly produced. The antennular flagella are damaged. The upper flagellum consists of two rami which are fused for the two proximal segments. The shorter ramus consists of two segments and bears two groups of aesthetascs. Five segments are still present on the lower ramus. Only four segments of the lower flagellum are still present.

The flagella are missing from the antennae. The basicerite bears a small blunt lateral process. The carpocerite is short and cylindrical. The scaphocerite is broad with a straight lateral border armed distally with a strong tooth. The lamina is roundly angled distally and distinctly exceeds the disto-lateral spine.

The eye is large with an obliquely orientated hemispherical cornea. The eyestalk is robust with a maximum length about 1.5 times the breadth. The width of the stalk is distinctly greater than the diameter of the cornea. A small accessory pigment spot is present close to the corneal margin dorsally.

The mandible is without a palp. The molar process is robust with a long finger-like process posteriorly. The medial dorsal border bears a small number of long stout setae. The incisor process is slender with five small distal teeth. The maxillula bears a small feebly bilobed palp. The lower lobe bears a small uncinate seta. The upper lacinia is stout and tapers distally, bearing seven stout spines at its distal end and two plumose setae on its lower border. The lower lacinia is slender with a few short slender simple setae distally. The maxilla bears a stout, non-setose palp. A broad bifid endite is present with five simple setae on the distal lobe and three on the proximal lobe. A feebly developed process is present on the medial border proximal to the endite. The scaphognathite is well developed, broad anteriorly and very narrow posteriorly. The first maxilliped has a well developed palp bearing a single non-plumose seta at two thirds of its length. The endite is broadly rounded distally and with an entire medial border, slightly emarginated proximally, bearing a few long plumose setae proximally and spinulose setae distally. The exopod is well developed and has a small caridean lobe. The epipod is small and distinctly bilobed. The second maxilliped has a dactylus bearing short stout spinulose setae. The propodus is broad, 1.5 times longer than wide and with a few plumose setae at the antero-medial angle. The exopod is well developed but the epipod is small, sub-rectangular and without a podobranch. The third maxilliped has a normally developed endopod. The terminal and penultimate segments are subequal in length and together slightly shorter than the

antepenultimate segment. The terminal segment bears a few long slender non-serrated setae and a number of short simple setae along the distal half of its medial border. The penultimate segment bears only two simple setae medially. The antepenultimate segment is three times longer than wide and bears sparse simple setae along its medial border. The distal third of its lateral border is armed with a row of five stout similar spines, which are equal in length to the width of the segment. The exopod is well developed and slightly exceeds the antepenultimate segment. The basis is obscurely separated from the ischiomerus and from the coxa. Its lateral border is short and bears the exopod while the medial border is much longer and strongly convex, bearing a single simple seta. The coxal segment is short with a small median lobe and a small rounded epipod laterally. A large arthrobranchial rudiment is present.

The first pereiopod is short and stout. The fingers are broadly sub-spatulate, with entire cutting edges and are longer than the palm which is subcylindrical. The carpus is distinctly shorter than the chela (61 : 83) and is slender, narrower proximally than distally and unarmed. The merus is slightly shorter than the chela (76 : 83) but is distinctly longer than the ischium (83 : 54). Only the left second pereiopod is preserved. The chela is robust with a cylindrical palm, slightly swollen in the middle. The fingers are stout and about 0.3 times the length of the palm. The fixed finger bears a stout curved peglike process distally, separated by a deep notch from the cutting edge which bears a row of acute proximally directed teeth. A few long setae are also present. The dactylus fits into the notch between the tip and the cutting edge of the fixed finger. The cutting edge is similarly serrated but the teeth are more numerous and more acute. The carpus is short, stout and unarmed, nearly three times as wide distally as proximally and about half of the length of the palm and the ischium is about 0.8 of the length of the merus: both segments are unarmed. The ambulatory pereiopods are slender. In the third pereiopod the dactylus is a quarter of the length of the propodus. The unguis is very clearly marked and is about 0.6 times the length of the main part of the dactylus, which bears well marked anterior and posterior accessory spines, thereby giving the dactylus a triunguiculate appearance. A pair of lateral setae are also present. The propodus tapers slightly distally and is about 7.8 times longer than wide. A pair of stout spines are present at the distal end of the posterior border with a single smaller seta proximally. Several long slender setae arise from the distal end of the posterior border. The carpus is short and relatively stout, 0.38 times the length of the propodus and unarmed. The merus is slightly more robust than the propodus and 1.7 times the length of the ischium. Both merus and ischium are unarmed. The fourth and fifth pereiopods, only present on the left side, appear generally similar. The sternite of the fourth thoracic segment lacks a median process. The endopod of the first pleopod is a small rounded, non-setose lobe. The endopods of the second to fifth pleopods are well developed with appendices internae on the medial borders. The uropods are well developed, with the exopod extending beyond the endopod, which in turn exceeds the tip of the telson. The lateral margin of the exopod is straight and non-setose, with a small mobile spinule distally. The posterior border is rounded and heavily setose.

HOST: *Comanthina schlegeli* (P. H. Carpenter) (Echinodermata: Crinoidea).

REMARKS: The specimen was found on the same host crinoid as the specimen of *Palaemonella pottsi* referred to above.

The very small size of the single specimen indicates that it is juvenile, probably the first post-larval stage.

The most noteworthy features of the present specimen are the dentate rostrum, the supraocular teeth and the lack of the hepatic spine. In the genus *Periclimenes*, which this species otherwise closely resembles, the hepatic spine is present in the first larval stage. This combination of features is found only in *Araiopontonia*, a monospecific genus at present represented by a single specimen of *A. odontorhyncha* Fujino & Miyake (1970). *Araiopontonia* is closely related to *Parapontonia* Bruce (1968) in which genus the only

species, *P. nudirostris*, is known to associate with crinoids, so that a similar association probably occurs in the case of *Araiopontonia*. The dactylus of the ambulatory pereiopods in the present specimen shows a particularly close resemblance to that of *A. odontorhyncha*, with a well developed acute accessory spine on the ventral border and also a slender spine on the dorsal aspect, at the base of the unguis. This feature is also present, but less well developed in *Periclimenes commensalis* Borradaile, a species that has already been recorded from crinoids in Queensland (Bruce, 1971)

The mouthparts also show a close resemblance to both *A. odontorhyncha* and *P. commensalis* but differ conspicuously from both in the remarkable series of large spiniform setae on the disto-lateral margin of the ischiomerus of the third maxilliped. These are without parallel in any other pontoniine species but some small spines may exist in this situation in the adults of some species, such as *Periclimenes elegans* (Paulson, 1875) and *P. grandis*, (Bruce, 1976). The One Tree Island shrimp has a normal incisor process on the mandible, and lacks the broadly expanded process found in *A. odontorhyncha*. The endite of the maxilla is bilobed, as in *A. odontorhyncha* and also in most commensal species of *Periclimenes*, and is not simple as in *P. commensalis*, (Bruce, 1971). The simple palp in this specimen of *P. commensalis* however, may be atypical and due to individual variation only.

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THE LEAFHOPPERS AND FROGHOPPERS OF AUSTRALIA AND NEW ZEALAND

(Homoptera: Cicadelloidea and Cercopoidea)

Part 2

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SUMMARY

New genera and new species of Australian and New Zealand Cicadelloidea and a new species of Cercopoidea, described from Australia subsequent to the publication of *'The Leafhoppers and Froghoppers of Australia and New Zealand'* (Evans, 1966), are listed. Particulars are given of changes in classification and nomenclature and of new knowledge acquired during the past decade. Two new genera of Eurymelidae are described (*Iposa*, type species: *Anipo fusca* Evans and *Relipo*, type species: *R. oenpellensis* sp. n.); also a new species, *Ipoella douglasi*. The classification of the Cephalelini is reviewed and, as a result, some described genera are removed from synonymy and re-described and two new genera described (*Linacephalus*, type species: *Paradorydium michaelseni* Jacobi, and *Alocephalus*, type species: *Dorycephalus ianthe* Kirkaldy). The first representative of the Myerslopiini to be recorded from Australia is described (*Myerslopella* gen. nov., type species: *M. taylori* sp. n.) and the antiquity of the tribe discussed. Other Cicadellidae described are as follows: *Paradorydium narrabrensis, Austroagalloides moorei* and *Stenogiffardia* gen. nov., type species: *S. elongata* sp. n. (Platymetopiini).

INTRODUCTION

More than a decade has passed since Australian Museum Menoir XII, which bore the same title as the present work, was published (Evans, 1966). In the intervening years several new genera and new species of Australian and New Zealand Cicadelloidea and a single new species of Australian Cercopoidea have been described by various authors. Changes have also been made in nomenclature, new synonymies proposed, transfers have taken place between tribes and subfamilies and new distribution records established.

The particular purpose of this paper is to provide information on these matters under one cover. At the same time the opportunity is taken of correcting errors in the former work, of changing some previously proposed generic concepts and of describing some new genera and species, most of which are of special interest.

It needs to be emphasised once again that these insects, as they occur in Australia, provide a fascinating and extensive field of research and that this paper and its predecessor are essentially no more than preliminary frameworks to serve as a basis for future studies.

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Records of The Australian Museum, 1977, **Vol. 31 No. 3,** 83-129, Figures 1-12

The New Zealand leafhopper fauna, thanks to the recent studies of Knight, is now, on the other hand, well known (Knight, 1973, b; 1973, c; 1974, a; 1974, b; 1975). It is of interest to note, while extensive collecting in New Zealand and critical studies of the fauna have enabled the description of an abundance of new species, that no new genera have been recognized in the more ancient groups, each of which is still represented by only a single genus, four of which are endemic *Novolopa* (Ulopini), *Paracephaleus* (Cephalelini), *Myerslopia* (Myerslopiini), *Novothymbris* (Thymbrini), *Zelopsis* (Macropsinae)). For reasons given on page 100 the occurrence of the non-endemic genus (*Paracephaleus*) in New Zealand is difficult to explain.

THE SUPERFAMILIES OF THE CICADELLOIDEA

In Part I the Membracidae were considered as one of the families of the Cicadelloidea.

Recently, Strümpel (1972) has proposed a system of classification whereby the Membracidae, Aetalionidae, Biturritidae and Nicomiidae, are associated together in a separate superfamily, the Membracoidea.

While accepting the distinctiveness of this assemblage of closely related families, it has been suggested previously that it may be misleading to give the group superfamily terminology for this suggests equivalence of evolutionary status with the Cicadoidea and the Cercopoidea, while surely it is the common stem of the Membracoidea and the Cicadelloidea which has such equivalence? (Evans, 1975).

Another possibility respecting the inter-relationships of the superfamilies of the Auchenorrhyncha is expressed in Figure 1. This is based on the currently widely supported, though by no means universally accepted, 'sister-group' concept of evolutionary diversification.

While the association of the Membracoidea with the Cicadelloidea, as shown in the figure is undoubtedly correct, there is less certainty respecting the placing of the Cercopoidea as a sister group of the Cicadoidea and such an arrangement pre-supposes the persistence in time of all the principal branches of the Auchenorrhyncha. In other words, it assumes there have existed in the past no equally highly distinctive groups which have now become extinct.

CICADELLOIDEA
EURYMELIDAE
SPECIES DESCRIBED FROM AUSTRALIA SINCE EVANS, 1966

Cornutipo bakeri Evans

Proc. R. Soc. Qd. 81 : 51, 1969.

Type Locality — Ashburton, Western Australia.

Type Location — Australian Museum.

Ipo moorei Evans

Proc. R. Soc. Qd. 81 : 54, 1969.

Type Locality — Normanton, Queensland.

Type Location — Australian Museum.

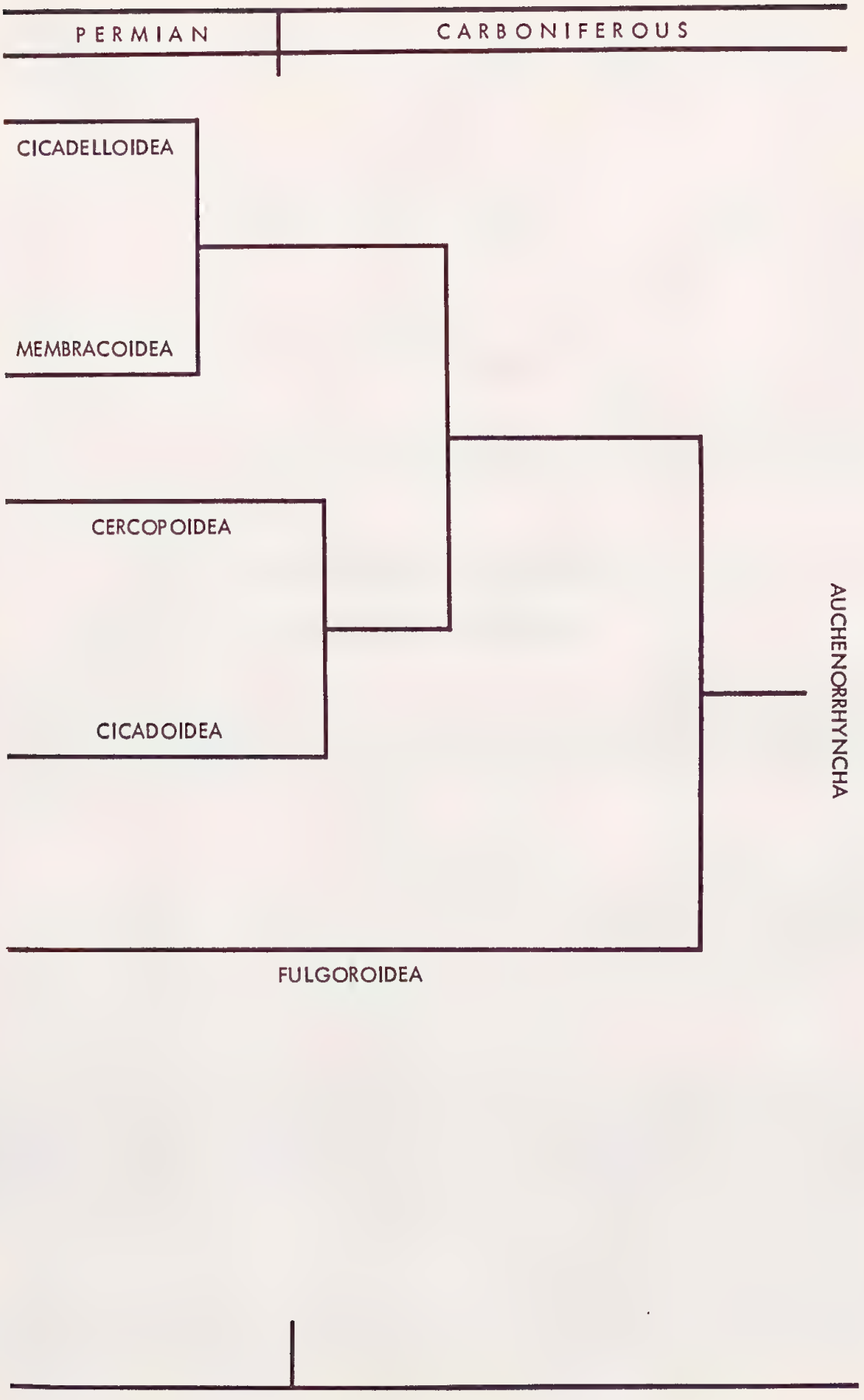

Fig. 1. The Phylogeny of the Auchenorrhyncha

Ipo minor Evans

Proc. R. Soc. Qd. 81 : 54, 1969.

Type Locality — Charters Towers, Queensland.

Type Location — Australian Museum.

Ipoella wallacei Evans

Pacif. Ins. 15 : 186, 1973.

Type Locality — Millstream area, Western Australia.

Type Location — Australian Museum.

Eurymela intermedia Evans

Proc. R. Soc. Qd. 81 : 55, 1969.

Type Locality — Narrabeen, New South Wales.

Type Location — Australian Museum.

SPECIES DESCRIBED FROM NEW GUINEA SINCE EVANS, 1966[1]

Ipoides eramboensis Evans

Pacif. Ins. 15 : 186, 1973.

Type Locality — Eramboe, S.W. New Guinea.

Type Location — Bishop Museum, Honolulu.

Ipoides maculata Evans

Pacif. Ins. 15 : 187, 1973.

Type Locality — Eramboe, S.W. New Guinea.

Type Location — Bishop Museum, Honolulu.

Iposa gen. nov.

Small eurymelids resembling species of the genus *Ipoella* Evans in general characteristics and, in particular, in having a single spine mounted on an enlarged base on the hind tibiae. Differing from *Ipoella* spp. in size, being considerably smaller; in having three, instead of more than three veins between R and the costal margin, in having broader subgenital plates with medial, instead of marginal, accessory clasping processes and hind tibiae, which as well as having a mounted spine, have also three rows of long, strong, marginal spines.

Type species — *Anipo fusca* Evans

1 New species listed from New Guinea are ones which belong essentially to the Australian, rather than to the Oriental fauna.

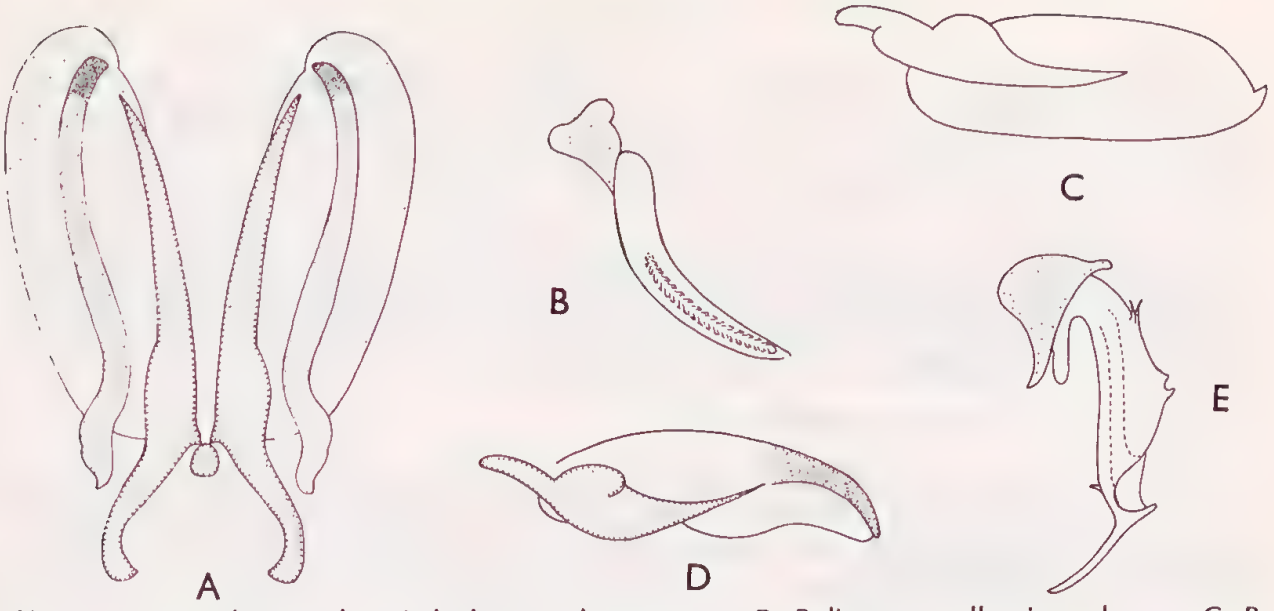

Fig. 2. A, *Iposa fusca*, subgenital plates and parameres; B, *Relipo oenpellensis*, aedeagus; C, *R. oenpellensis*, subgenital plate and paramere; D, *Ipoella douglasi*, subgental plate and paramere; E, *I. douglasi*, aedeagus.

Iposa fusca (Evans) comb. nov.
(Fig. 2A)

Anipo fusca Evans 1941, Trans. Roy. Soc. W. Aust. 27 : 193.

Ipoella fusca (Evans) — Evans, 1966 : 44.

The aedeagus of this small (3.5 mm), distinctive eurymelid has been illustrated previously (Evans, 1941). The subgenital plates and parameres are shown in Fig. 2A. It is seemingly confined to Western Australia, where it has been taken at Perth (type locality) and Pingelly.

Ipoella douglasi sp. n.
(Fig. 2D, E)

Length, ♂, 4.8 mm; ♀, 5.2 mm. Overall coloration, pale brownish yellow. Resembling other species in the genus *Ipoella* in cephalic, tibial and general male genitalia characteristics and differing from them in the shape of the aedeagus, in particular in having a long, acute proximo-ventral extension.

Holotype ♂, and Allotype ♀, Three Rivers Station, Western Australia, 1-75, A. Douglas, in the Western Australian Museum.

I. douglasi, which resembles *Ipoella brunneus* Evans, is given specific recognition because of the particularly distinctive shape of its aedeagus and because its description provides an opportunity of once more drawing attention to the high degree of variability existing within the Eurymelidae. This applies both to tegminal colour pattern and, within certain genera, to the shape of the several parts of the male genitalia.

This variability serves to make species selection difficult and a matter of personal choice. If specific status were to be granted to representatives of every population showing minor colour pattern and male genitalia differences, it would lead to the recognition of an endless multiplicity of species. In Part I differently shaped aedeagi of four insects, all ascribed to *I. brunneus*, were illustrated (Evans, 1966, Fig. 10, C3-6).

Relipo gen. nov.

The anteclypeus, which lies at a lower level than the postclypeus, is anteriorly depressed. The postclypeus is convex, and though the epistomal suture is not apparent, the attachments of the cibarial muscles do not extend onto the frontal region. The ocelli, which lie close to the apices of the obscure epicranial suture, are prominent. The rounded crown is widest against the eyes. The tegmina, which are broadly rounded apically, have narrow appendices and numerous short veins between R and the costal margin. The hind tibiae have each a row of five strong spines, of which the most distal one is mounted on an enlarged base. They bear, in addition, a row of small spines and another of long hairs. In the male genitalia the subgenital plates are parallel-sided.

Type species — *Relipo oenpellensis* sp. n.

Relipo resembles *Aloipo* Evans in having a convex frontoclypeus. It differs from *Aloipo* in having a depressed anteclypeus, in the restriction of the attachment of the cibarial muscles to the postclypeus and from all other genera of the Eurymelidae in characters furnished by the male genitalia.

Relipo oenpellensis sp. n.
(Fig. 2B, C)

Length, ♂, 4.6 mm, ♀, 5.3 mm. General coloration brownish-yellow. Vertex of head, pronotum and scutellum covered with fine hairs. Head and pronotum deep yellow. Scutellum concolorous with the pronotum, lateral muscle impressions sometimes dark brown. Tegmen with a covering of fine hairs, hyaline brown; veins brown, or reddish; appendix with a pair of brown markings. Male genitalia as in Fig. 2B, C. Holotype ♂ and Allotype ♀, Birraduk Creek, 18 km. E. by N. of Oenpelli, Northern Territory, 1-VI-73, T. Weir and H. Forester, in the A. N. I. C., Canberra. 1 Paratype ♂, Eldo, 5 km. S. of Gove Airport, N. T. in the author's collection.

NOTES ON THE EURYMELIDAE

Cornutipo tricornis (Evans)

In Part I this species was placed in the genus *Cornutipoides*, of which it was the type. This generic name has now been placed in synonymy with *Cornutipo* Evans, type species, *C. scalpellum* (Evans, 1969, a).

'For reasons difficult to define' it was suggested in Part I that *C. scalpellum* and *C. tricornis* might be relict forms. Their supposedly primitive characteristics have now been described (Evans, 1969, a).

Ipo pellucida (F.)

Previously known only from Queensland, this species recently has been recorded also from the Northern Territory (Evans, 1969, a).

Ipoella insignis (Distant)

For lack of available material the male genitalia were not figured in Part I. They have now been illustrated and the species recorded from Darwin, N. T. (Evans, 1969, a).

Bythoscopus anguliferus Walker, 1851

This name, which is a synonym of *Eurymeloides marmorata* (Burmeister), was omitted from Part I.

Bakeriana nigra Evans, *Ipoides hackeri* Evans, *Ipoides minor* Evans, *Eurymeloides punctata* Signoret, *Eurymelessa moruyana* (Distant)

The above species, all originally described from Australia, have now been recorded also from New Guinea (Evans, 1973).

Platyeurymela semifascia (Walker).

This eurymelid, which is somewhat beetle-like in appearance, is the sole known representative of the family, apart from those comprised in the Pogonoscopini, in which the tegmina are not tectiform. During March, 1969, a colony of eight adult insects were found under bark at Wilson's Valley, Mt. Kosciusko. This occurrence suggests their shape may have adaptive significance.

Systematic Status

As a result of studying characters provided by the female genitalia and metathoracic legs of a few selected groups of leafhoppers, Davis (1975) has suggested that the Eurymelidae are best regarded as a subfamily of the Cicadellidae.

It would seem that the author, in arriving at this opinion, has failed to pay attention to other morphological features of these insects and their special behavioural characteristics. It is on the latter, and on the characters provided more particularly by the venation of the tegmina, and the male genitalia, that a claim for family status for the Eurymelidae is based (Evans, 1966).

CICADELLIDAE

ULOPINAE

In Part I, this subfamily was considered to be represented in Australia by two component tribes, the Ulopini and the Cephalelini, and in New Zealand, as well as by these, also by a third tribe, the Myerslopiini.

Linnavuori (1972) has suggested that although the last named group may have been derived from the Ulopinae, it is so distinctive, that it merits subfamily status. For reasons given on page 100 this proposal has not been adopted here.

ULOPINI

SPECIES DESCRIBED FROM NEW ZEALAND SINCE EVANS, 1966

Novolopa falcata Knight

N. Z. Jl. Sci. 16 : 975, 1973.

Type Locality — Mt. Grey, Otago Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

Novolopa infulata Knight

N. Z. Jl. Sci. 16 : 976, 1973.

Type Locality — Mt. Barber, Otago Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

Novolopa maculata Knight

N. Z. Jl. Sci. 16 : 976, 1973.

Type Locality — Mt. Coronet, Otago Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

Novolopa kuscheli Knight

N. Z. Jl. Sci. 16 : 978, 1973.

Type Locality — Mt. Rakeahua, Stewart Island.

Type Location — D.S.I.R. Entomology Division, Auckland.

Novolopa montivaga Knight

N. Z. Jl. Sci. 16 : 978, 1973.

Type Locality — Old Man Range, Otago Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

CEPHALELINI

This group of relict Cicadellidae is of unusual interest since, unlike the Ulopini from which they are probably derived, the isolation of populations resulting from the break up of Gondwanaland has not led to striking generic differentiation.

In Part I two genera were recognized, one, *Cephalelus* Percheron, with representation in South Africa and Australia and the other, *Paracephaleus* Evans, occurring in Australia and New Zealand. These genera were distinguished by the shape of their heads, those in *Cephalelus* having their ventral surface convex, flattened, or slightly medially concave, while the faces of the heads of *Paracephaleus* spp. are percurrently concave.

A critical study of representatives of this tribe from Australia, South Africa and New Zealand has resulted in earlier views on inter-relationships being changed. As a result some genera previously placed in synonymy have needed to be re-established and are re-described and two new genera are recognized.

KEY TO THE GENERA OF THE CEPHALELINI

1. On the face of the head subgenal sutures and supra-antennal ledges lacking ..... *Cephalelus* Percheron (S. Africa)
   Type species: *C. infumatus* Percheron
   On the face of the head subgenal sutures and supra-antennal ledges present 2

2(1) Face of head percurrently concave; in forms lacking hind wings, venation obscure ..... *Paracephaleus* Evans (Australia and New Zealand)
   Type species: *P. montanus* Evans
   Face of head completely, or medially, flat 3

3(2) Crown of head convex; antennal ledges laterally prominent 4
   Crown of head flat, sometimes laterally carinate; antennal ledges moderately developed 5

4(3) Apex of head bulbous ..... *Procephaleus* Evans (Australia)
   Type species: *P. bulbosa* Evans

Apex of head not bulbous; sides approximately at right-angles to the dorsal surface ..... *Notocephalius* Jacobi (Australia)
Type species: *N. hartmeyri* Jacobi

5(3) Tegmen densely punctate; venation sometimes reticulate .....
Linacephalus gen. nov. (Australia)
Type species: *Paradorydium michaelseni* Jacobi
Tegmen largely hyaline; venation never reticulate 6

6(5) On the face of the head subgenal sutures oblique; male genitalia with parameres evenly slender ..... *Anacephaleus* Evans (Australia)
Type species: *A. minutus* Evans
On the face of the head subgenal sutures transverse: male genitalia with parameres irregularly-shaped..... *Alocephalus* gen. nov. (Australia)
Type species: *Dorycephalus ianthe* Kirkaldy

Anacephaleus Evans

1937, Pap. Roy. Soc. Tasm. 1936 : 46

Type species — Anacephaleus minutus Evans

There occur in south-western and south-eastern Australia representatives of a group of small, short-headed, Cephalelini which when first studied were regarded as comprising several species belonging to the above distinctive genus (Evans, 1937, 1939).

At a later date two of these species, *A. carribensis* Evans and *A. latus* Evans were placed in synonymy with the type species and the generic name was regarded as a synonym of *Cephalelus* (Evans, 1966). This action was taken as the character of length of head was then regarded, by itself, as insufficient for generic recognition and, although the male genitalia had been examined and illustrated, those of other representatives of the group had not, at that time, been investigated.

It is possible that, in time, the availability of long series of these insects from numerous localities may enable the recognition of several distinct species of *Anacephaleus*. Meanwhile, it seems preferable to recognize a single species only, contained in a genus which differs from others in the tribe in head length and shape and in having distinctive male genitalia. This genus is re-described below: —

Pale brown, or greyish insects, sometimes with pale, dark brown, or black, markings on the tegmina. Head, thorax and tegmina, in part, punctate. Fully winged ♀♀, 4.2-5.6 mm; heads, 0.8-1.2 mm. ♂♂ and ♀♀ lacking hind wings, 3.8-4.2 mm; heads, 0.8-1.0 mm.

On the face of the head the labium terminates between the middle coxae. The anteclypeus is swollen and pear-shaped and the postclypeus flat, parallel-sided, and margined by channel-like depressions. The subgenal sutures are distinct and oblique and the eyes are prominent. The supra-antennal ledges are transverse, laterally rounded and slightly raised, and the antennal depressions are deep. The tentorial arms are short, broad and T-shaped. The epistomal suture is obscurely defined and the frontal area depressed. The vertex is medially flat and sloping laterally. The crown of the head is broadly arrow-shaped with a median longitudinal ridge. The ocelli are situated midway between the fore and hind margins of the crown and in forms lacking hind wings may be functionless (white), or lacking. The largely hyaline tegmina are apically acute, the appendices are narrow and the veins prominent. The hind femora lack apical spines and the tibiae are narrow and parallel-side, the hind tibiae having a few small spines. In the male genitalia the ninth sternum is continuous with the pygophore, of which the hind margin has a median, narrow,

ventrally directed projection. The subgenital plates are proximally parallel-sided and distally foliaceous. The aedeagus has a large, proximal, dorsally=directed, open-ended process and is distally narrow and bifurcate. The parameres are long, narrow, and subapically curved.

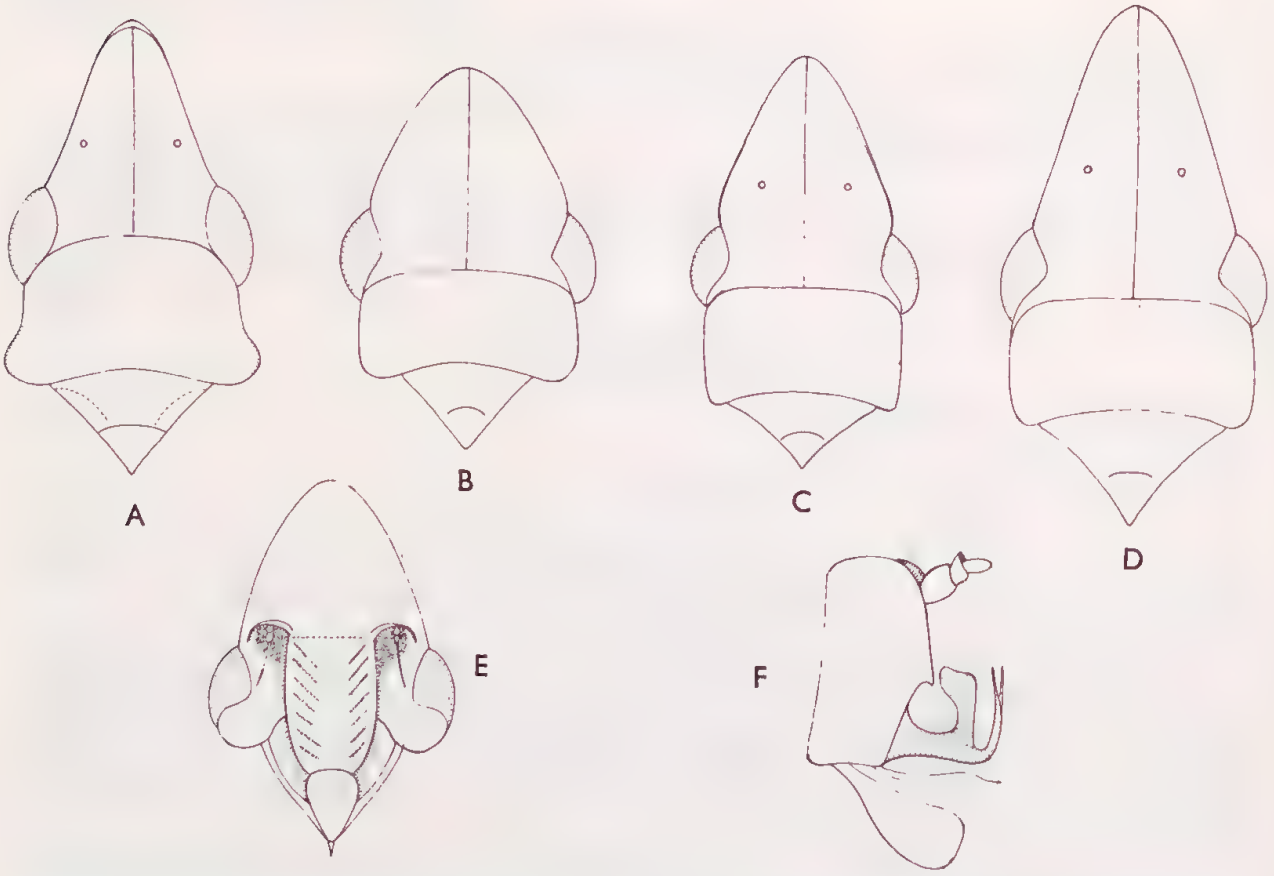

Fig. 3. *Anacephaleus minutus*, A, head and thorax, winged form; B-D, of forms lacking hind wings; E, face of head; F, male genitalia.

Anacephaleus minutus Evans
(Fig. 3A-F)

Anacephaleus minutus Evans, 1937, Pap. R. Soc. Tasm. 1936 : 43.

Anacephaleus carribensis Evans, 1937 : 44.

Anacephaleus ulopae Evans, 1937 : 44.

Anacephaleus latus Evans, 1939 : 45.

Cephalelus minutus (Evans) — Evans, 1966 : 91.

The range of head length, the face of the head, and the male genitalia are illustrated in Fig. 3. This species resembles ones comprised in the Ulopini more closely than any other Cephalelini. It may hence be regarded as the most generalised extant representative of the tribe.

New locality records: Cannington, V-59; Midland, V-60; Albany, Augusta, IX-66 (Western Australia); Kangaroo Is., IV-65; Forest, Victoria, III-63; Royal National Park IX-70; Katoomba, V-66; New England National Park, III-66 (N. S. W.).

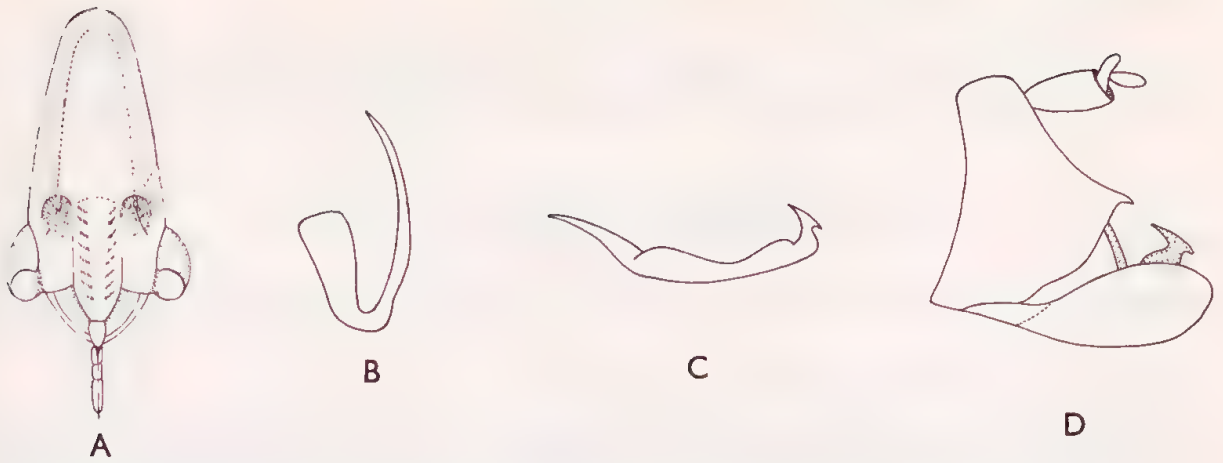

Fig. 4. *Alocephalus ianthe*, A, face of head; B, aedeagus; C, paramere; D, male genitalia.

Alocephalus gen. nov.

The head and thorax are punctate. The anteclypeus is pear-shaped and the maxillary plates are largely concealed by the lobe-like lora. The subgenal sutures are transverse and the genae swollen. The postclypeus is parallel-sided and flat. The antennal bases lie in circular depressions and the supra-antennal ledges are raised slightly above the level of the face. The frontal region is slightly medially depressed. The crown, which has an obscure median ridge, slopes slightly laterally. In forms lacking hind wings ocelli are present but functionless. The narrow tibiae are parallel-sided. The tegmina, which are slightly punctate, have distinct venation. In the male genitalia the pygophores narrow posteriorly and are continuous ventrally with the ninth sternum; the aedeagus is hook-shaped, the parameres long and hammer-shaped apically and the subgenital plates broad.

Type species — *Alocephalus ianthe* (Kirkaldy).

Alocephalus ianthe (Kirkaldy) (comb. nov.)
(Fig. 4A-D)

Dorycephalus ianthe Kirkaldy, 1906, Bull. Hawaii Sug. Plrs. Ass. Exp. Sta. 1 (9); 340.

Dorycephalus trilineatus Kirkaldy, 1906: 341.

Anacephaleus simplex Evans, 1937 : 44.

Cephalelus ianthe (Kirkaldy) — Evans, 1966 : 89.

♀♀ lacking hind wings, 6-6.8 mm; ♂♂ lacking hind wings, 5.8 mm. New locality records: Katoomba, N. S. W., V-66; Flinders, Victoria, XII-62.

Linacephalus gen. nov.

Densely punctate insects. The anteclypeus is pear-shaped and the exposed part of the maxillary plates are of equal length with the lora. The subgenal sutures are oblique and the genae swollen. The parallel-sided postclypeus is flat and the frontal region medially flat and laterally sloping. The crown is flat, has a prominent median ridge, and is marginally carinate. The tibiae are narrow and parallel-sided. In the male genitalia the pygophore is wider than long and the parameres are narrow, curved and apically acute.

Type species — Paradorydium michaelseni Jacobi

Linacephalus resembles *Alocephalus* in size, proportions and general appearance. It differs from *Alocephalus* in the structure of the male genitalia of the type species, in particular, in having parameres which are very differently shaped from those of *A. ianthe*.

Linacephalus michaelseni (Jacobi) (comb. nov.)
(Fig. 5B-E)

Paradorydium michaelseni Jacobi, 1909, Faun. S.W. Austral. Michaelsen u. Hartmeyer 2 : 339.

Cephalelus michaelseni (Jacobi) — Evans, 1966 : 91.

♂♂ lacking hind wings, 5 mm. The whereabouts of the type of this species is unknown. The illustrations are based on a specimen in the author's collection, which, like the type, is from Western Australia and which conforms with Jacobi's description and illustrations.

Linacephalus foveolatus (Signoret) (comb. nov.)

Dorydium foveolatum Signoret, 1880, Annls. Soc. Ent. Fr. (5) 10 : 44, Pl. 1, Fig. 3.

Cephalelus foveolatus (Signoret) — Evans, 1966 : 90.

The type of this species likewise has not been seen and the insect tentatively identified with it has been ascribed to this genus on the basis of Signoret's description and illustrations in particular, on the shape of the apically acute parameres. It differs from the type species in having a considerably longer head and in having subgenital plates which narrow apically.

Linacephalus subreticulatus (Kirkaldy) (comb. nov.)
(Fig. 5A)

Dorycephalus subreticulatus Kirkaldy, 1906, Bull. Hawaii. Sug. Plts. Ass. Exp. Stn. 1 (9): 340.

Cephalelus subreticulatus (Kirkaldy) — Evans, 1966 : 91.

As the holotype of this species is a female it is only tentatively ascribed to this genus.

Notocephalius Jacobi

1909, Faun. S.W. Aust., Michaelsen u. Hartmeyer 2: 339.

Densely punctate insects with white hair-like scales. The anteclypeus is oval, the maxillary plates narrow and the subgenal sutures oblique. The postclypeus, which widens posteriorly, is flat. The antennal bases lie in deep oval depressions and the supra-antennal ledges are modified as triangular lateral depressions. The eyes are prominent and the frontal region is percurrently concave. The apically rounded crown is convex and has an obscure, median, longitudinal ridge. The ocelli, in wingless forms, are functionless (white). The apically acute tegmina are densely punctate and have numerous costal veinlets, and the veins are in relief. The fore femora are swollen and the hind tibiae have small, evenly spaced, marginal spines. In the male genitalia the pygophore, posteriorly, has a broad, apically acute process, and the ninth sternum is rectangular.

Type species — Notocephalius hartmeyeri Jacobi

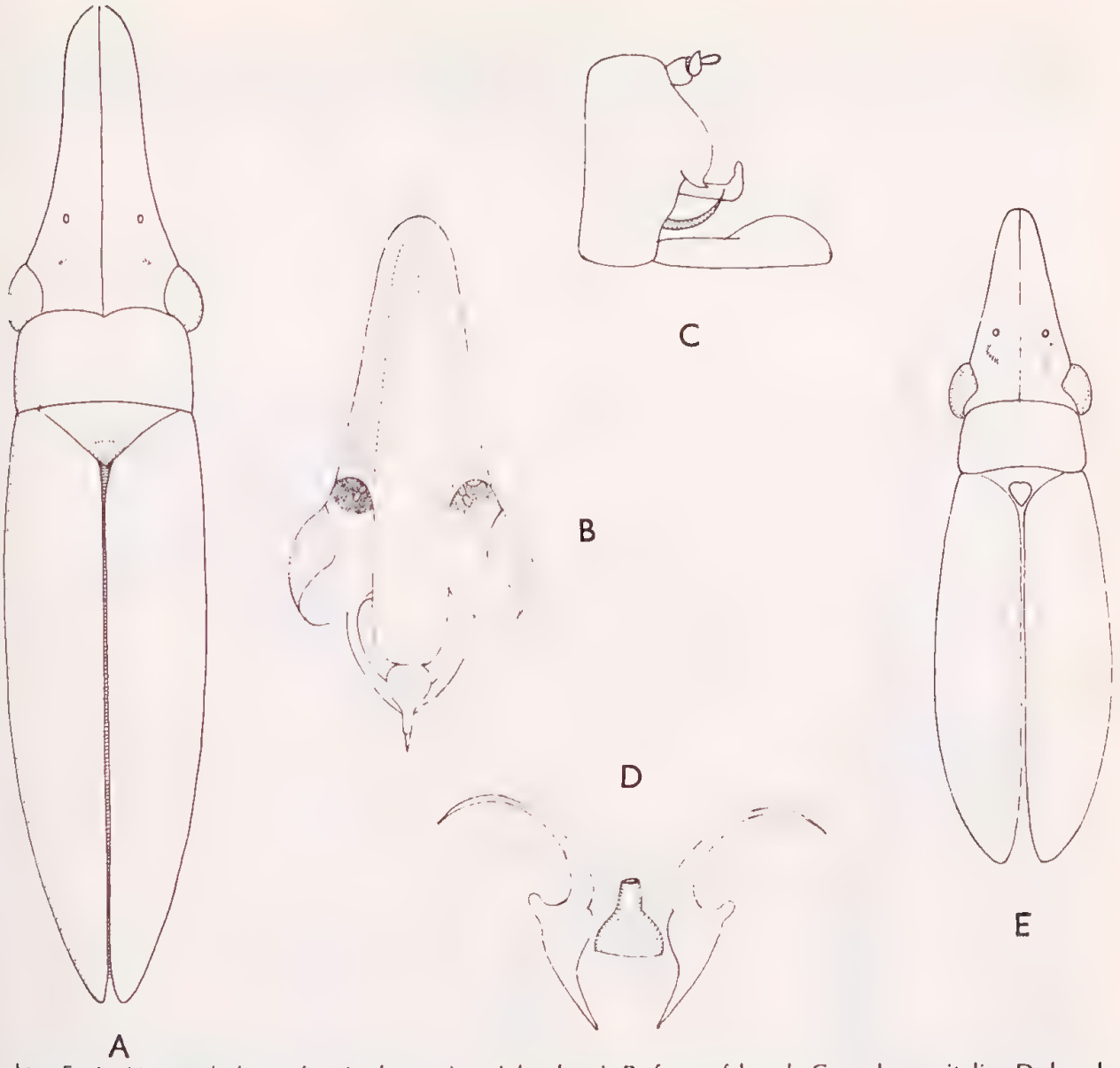

Fig. 5. A, *Linacephalus subreticulatus; L; michaelseni*, B, face of head; C, male genitalia; D, basal connective and parameres; E, whole insect.

Notocephalius hartmeyeri Jacobi
(Fig. 6A-E)

Notocephalius hartmeyeri Jacobi, 1909, Faun. S. W. Aust., Michaelsen u. Hartmeyer 2: 339.

Anacephaleus punctatus Evans, 1937: 45 (syn. nov.)

♀♀ lacking hindwings, 9 mm, head, 4 mm; ♂♂ lacking hindwings, 8.3 mm, head, 3 mm. Previously this species has been incorrectly regarded as a synonym of *Cephalelus marginatus* Waterhouse (Evans, 1966). New locality records: Wyndham, W. Australia, VI-65; Cooper Pedy, S. Australia, VIII-69; Kiata, III-63; Bogan River, X-32, Victoria.

Procephaleus Evans

1937, Pap. Roy. Soc. Tasm. 1936: 43.

Punctate, crown and thorax rugose. The apex of the head is knob-shaped and the face is

finely spinose. The anteclypeus is pear-shaped and the subgenal sutures slightly oblique. The maxillary plates are largely concealed by the lora. The postclypeus is flat and parallel-sided posteriorly and the frontal region is depressed laterally below the level of the vertex. The deep antennal depressions are circular in shape and the supra-antennal ledges consist of prominent, lateral, semi-circular lobes.

Type species — *Procephaleus bulbosa* Evans.

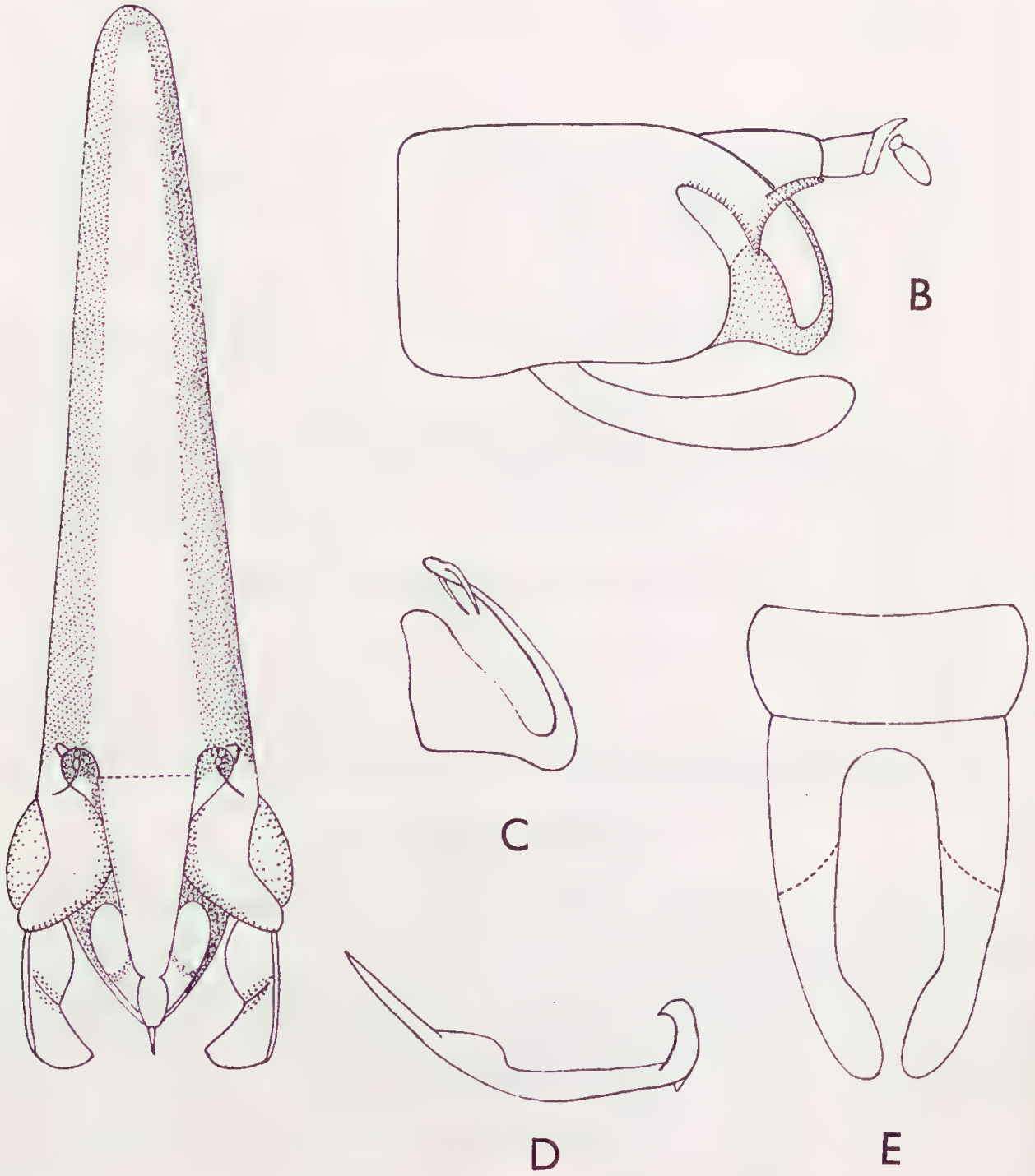

Fig. 6. *Notocephalius hartmeyeri*, A, face of head; B, male genitalia, C, aedeagus; D, paramere; E, ninth sternum and subgenital plate.

Procephaleus bulbosa Evans
(Fig. 7A, B)

Procephaleus bulbosa Evans, 1937, Pap. R. Soc. Tasm. 1936: 43.

Cephalelus bulbosa (Evans) — Evans, 1966: 91.

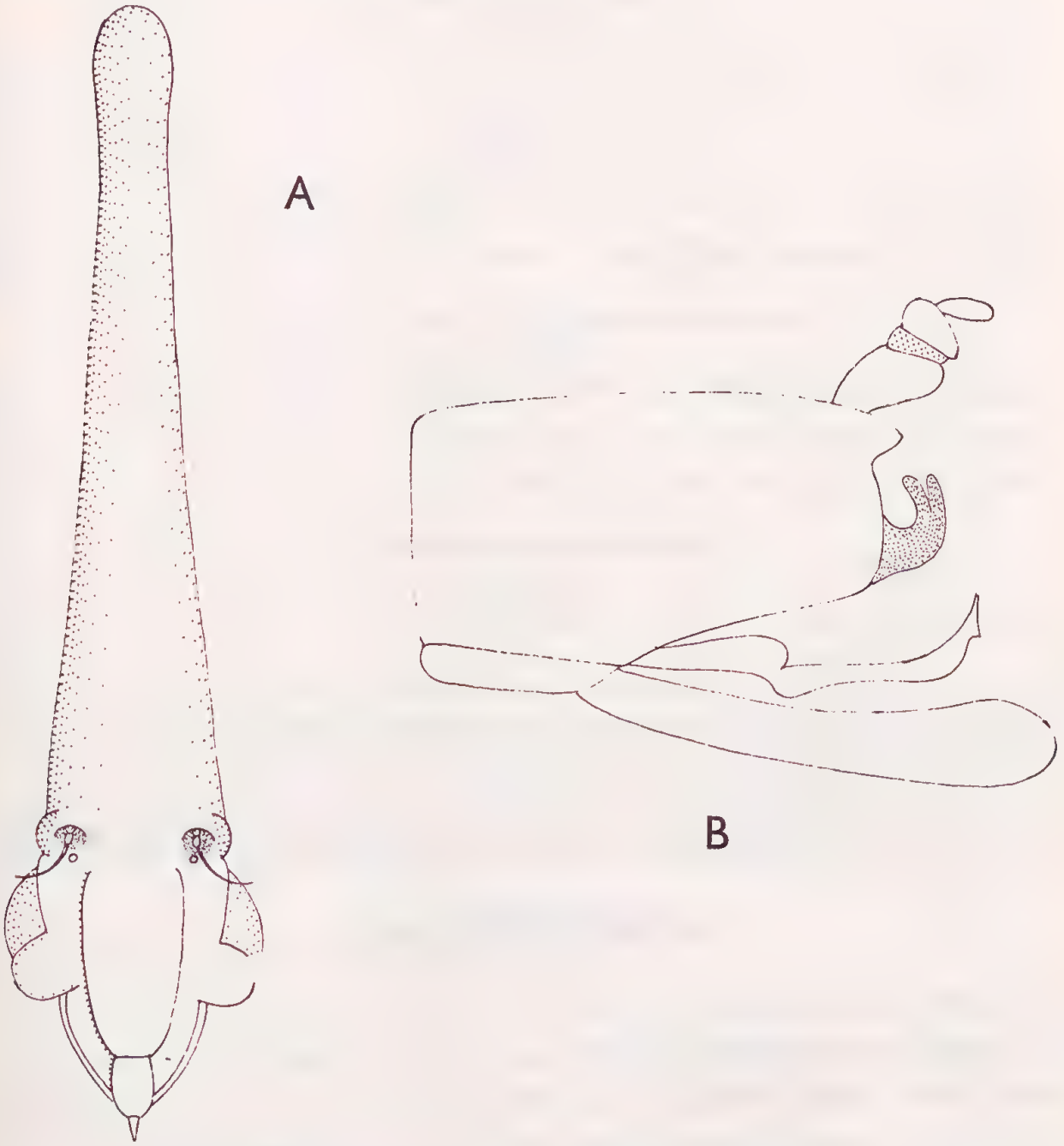

Fig. 7. *Procephaleus bulbosa*, A, face of head; B, male genitalia.

Paracephaleus Evans

1942, Proc. Roy. Soc. Qd. 54: 49.

This genus, which is the only one belonging to the older element of the Australian

cicadellid fauna to be represented also in New Zealand, has recently been re-described (Knight, 1973). The highly specialised species of this genus have characteristic male genitalia.

Type species — *Paracephaleus montanus* Evans

Paracephaleus montanus Evans
(Fig. 8A-E)

Paracephaleus montanus Evans, 1942, Proc. R. Soc. Qd. 54: 50.

Paracephaleus brunneus (Waterhouse)
(Fig. 8I, J)

Cephalelus brunneus Waterhouse, 1839, Trans. ent. Soc. Lond. 2: 195.

Paracephaleus brunneus (Waterhouse) — Evans, 1966: 93.

Paracephaleus marginatus Waterhouse (comb. nov.)
(Fig. 8L-O)

Cephalelus marginatus Waterhouse, 1839, Trans. Ent. Soc. Lond. 2: 195.

Cephalelus marginatus Waterhouse — Evans, 1966: 92

Cephalelus punctatus Evans, 1939: 46 (syn. nov.).

Paracephaleus dobsonensis Evans
(Fig. 8F-H)

Paracephaleus dobsonensis Evans, Aust. Mus. Mem. XII: 93.

Paracephaleus pallidus Evans

Paracephaleus pallidus Evans, 1947, Ann. Mag. Nat. Hist. 14: 146.

Paracephaleus pallidus Evans — Knight, 1973, c.

This species, which formerly has been regarded as a synonym of *P. brunneus* (Evans, 1966) has, according to Knight (1973c), distinctive male genitalia and hence merits specific recognition.

Paracephaleus hudsoni (Myers)
(Fig. 8K)

Cephalelus hudsoni Myers, 1923, Trans. N. Z. Inst. 54: 417.

Cephalelus leptocarpi Myers, 1923: 420.

Paracephaleus hudsoni (Myers) — Evans, 1966: 94.

Paracephaleus hudsoni (Myers) — Knight, 1973c: 952.

This New Zealand species closely resembles *P. montanus* (Knight, 1973c).

Paracephaleus curtus Knight

Paracephaleus curtus Knight, 1973, N. Z. J. Sci. 16: 985.

This New Zealand species closely resembles *P. montanus* (Knight, 1973c).

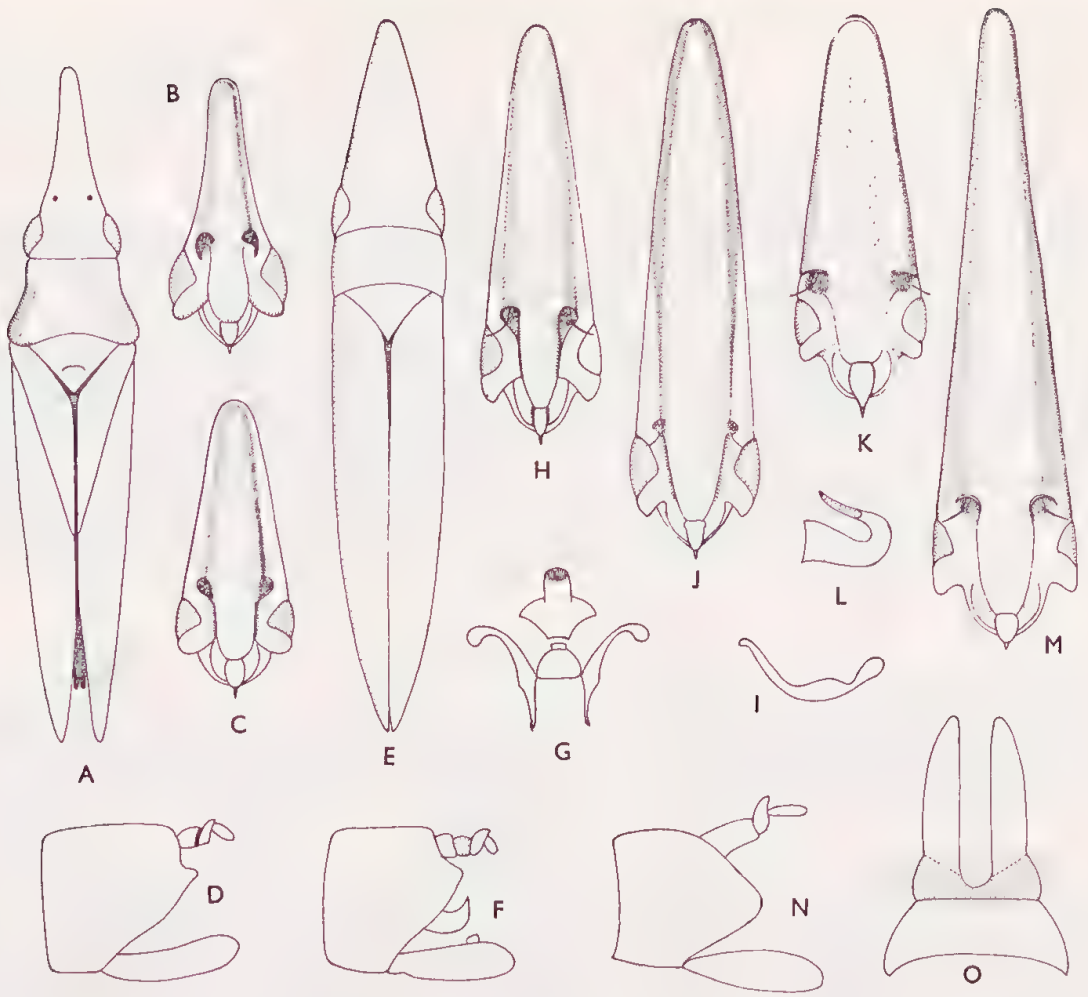

Fig. 8. *Paracephaleus montanus,* A, winged form; B, face of head, winged form; C, face of head, wingless form; D, genital capsule and subgenital plate; E, form lacking hind wings. *P. dobsonensis,* F, male genitalia; G, aedeagus, basal connective and parameres; H, face of head. *P. brunneus,* I, paramere; J, face of head. K, *P. hudsoni,* face of head. *P. marginatus,* L, aedeagus; M, face of head; N, genital capsule and subgenital plate; O, ninth sternum and subgenital plates.

Cephalelus Percheron

Cephalelus Percheron, 1832, Mag. Zool. 9: 48.

Type species — *Cephalelus infumatus* Percheron.

Because of a shared cephalic characteristic the Australian genera *Notocephalius, Procephalius* and *Anacephaleus* have previously been placed in synonymy with *Cephalelus* (Evans, 1966).

A re-examination of South African species ascribed to this genus suggests they are sufficiently different from any Australian Cephalelini to merit segregation in a separate genus. Thus, in *Cephalelus* spp. subgenal sutures and well-defined supra-antennal ledges are lacking; the tegmina are apically rounded and not acute and in the male genitalia, while the ninth sternum is variously shaped, it is never rectangular, and the tenth segment is of considerable size. The male genitalia of the type species, and of C. *angustatus* Evans and C. *bicoloratus* Evans, have recently been illustrated (Linnavuori, 1972).

NOTES ON THE CEPHALELINI

Since the most generalised Cephalelini are restricted to Australia, which has also the richest and most diverse fauna of these insects; it may be supposed that the group was derived from the Ulopini in the Australian component of Gondwanaland from where it will have spread, via Antarctica, to South Africa and New Zealand.

As a very considerable period of time must have elapsed since populations became isolated in these three separate land areas it might be anticipated that their isolation would have been accompanied by marked generic differentiation.

While this has occurred in Australia and, to a lesser extent, in South Africa, it has not happened in New Zealand. Moreover, not only do the two species recorded from New Zealand belong to a genus (*Paracephaleus*) represented also in Australia but each is closely related to an Australian species (Knight, 1973, c). Furthermore, the genus *Paracephaleus* is a highly specialised one unlike, for example, the New Zealand genus representative of another ancient Australian group of leafhoppers, the Thymbrini. This genus (*Novothymbris*) seems to lie close to the base of its particular tribal stem, and hence, presumably represents an ancient faunal association.

MYERSLOPIINI

As has already been mentioned, Linnavuori, in a recent paper (1972), has given this group of relict leafhoppers subfamily status on the grounds that they have several distinctive characteristics not shared with the Ulopini. At the same time he has acknowledged that they are 'evidently derived from the Ulopinae stock'.

The Myerslopiini are here retained as a tribe of the Ulopinae on the basis of arguments advanced previously (Evans, 1968) and because such an arrangement serves best to express their probable relationships. Furthermore, if they were to be given subfamily rank, then it would mean the equally distinctive Monteithiini, which are confined to New Guinea, would need to be similarly treated. The last-named tribe, which Linnavuori accepts as belonging to the Ulopinae on the basis of their cephalic and hind tibial structure, share with the Myerslopiini the character of having rudimentary pronotal paranota.

In the same paper *Evansiola* China is listed as belonging to the Megophthalminae (Linnavuori, 1972). This genus is, however, a component of the Myerslopiini (Evans, 1968).

The first representative of the Myerslopiini to be recorded from Australia is described below.

Myerslopella gen. nov.

Minute cicadellids having the greater part of the external surface punctate and covered with small white hairs and papillae. On the face of the head the labium extends to between the middle and hind coxae and the parallel-sided anteclypeus is anteriorly depressed. The postclypeus and the frontal region are medially depressed. The maxillary plates are wide and the antennae, which have two large basal segments, are long. The laterally situated antennal ledges are in continuous alignment with the sides of the postclypeus. A pair of deep channels between the anterior margins of the eyes and the base of the maxillary plates extends from the antennal depressions to the sides of the head. The crown of the head, which is apically spatulate, is medially depressed. Ocelli are lacking. The pronotum is medially elevated and laterally depressed and the lateral margins consist of a pair of small backwardly-projecting lobes. The brachypterous tegmina are postero-medially depressed. The fore and middle tibiae have numerous small, stout spines; the hind femora lack apical spines and the heavily spined hind tibiae have six spines in the row of strongest spines. The

abdomen, which is globose, has a series of three pairs of prominent crests, the median pairs being situated on abdominal segments 2-5; the dorso-lateral pairs on segments 2-4 and the lateral pairs on segments 2 and 3.

Type species — Myerslopella taylori n. sp.

Myerslopella resembles *Myerslopia* Evans (New Zealand), *Paulianiana* Evans (Madagascar) and *Evansiola* China (in particular *E. selkirki* Evans (Juan Fernandez Island)), in having an extensive flattened crown and small lateral pronotal paranota. It resembles *Paulianana* and *Evansiola* (*E. kuscheli* China) in having prominent crests on several of its abdominal segments and the last named species also in having two-segmented tarsi (a juvenile characteristic). It differs from the two last named genera in the crests being laterally, and not medially, situated and from all previously described genera in having broad maxillary plates and antennae situated close to the anterior margins of the eyes.

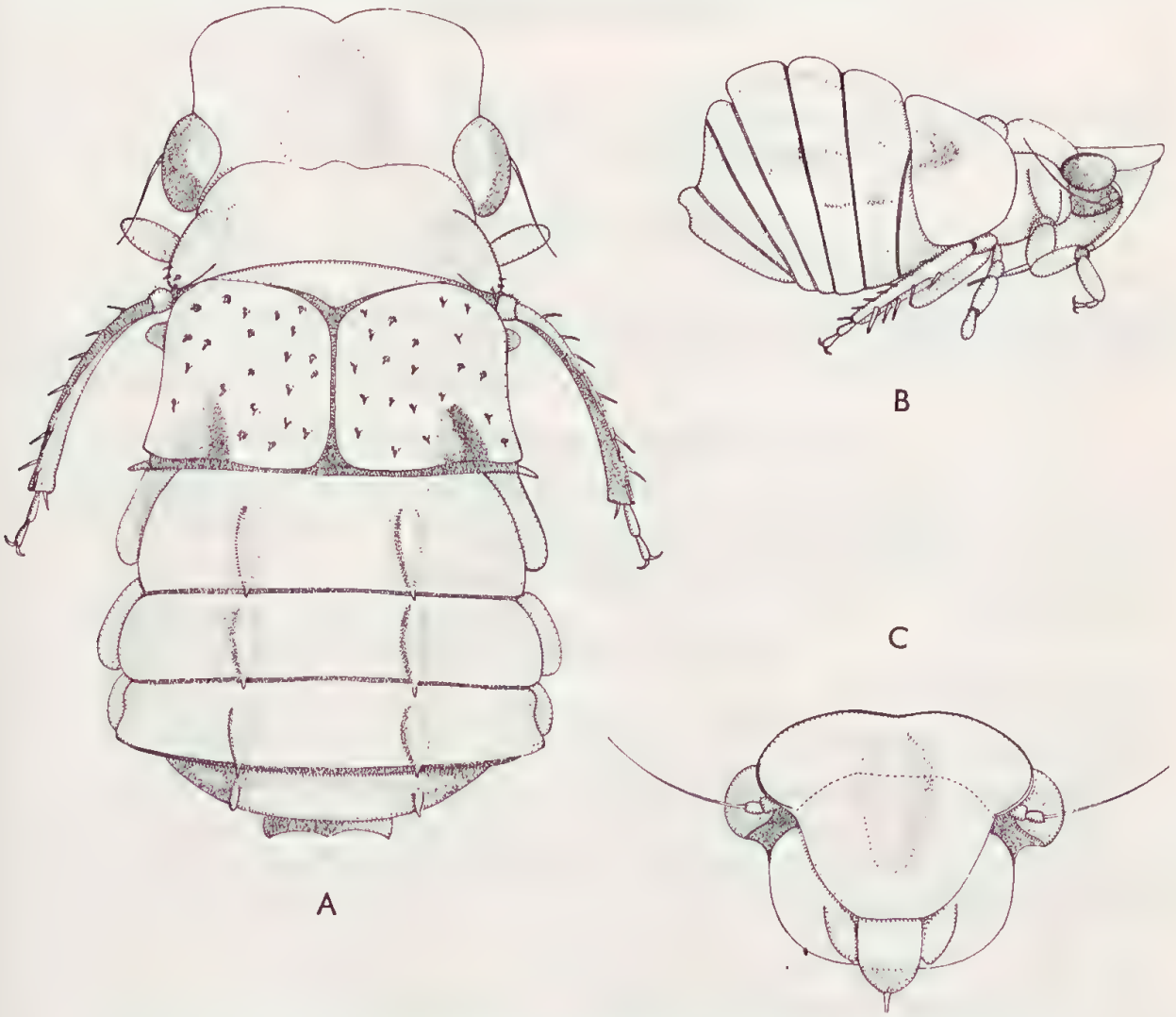

Fig. 9. *Myerslopella taylori*, A, in dorsal aspect; B, lateral aspect; C, face of head.

Myerslopella taylori sp. n.
(Fig. 9A-C)

Length, ♀, 1.8 mm. General coloration, shining brown. Crown of head extensive, approximately rectangular in shape. Tegminal lobes pad-like, heavily pitted. Legs with two

tarsal segments. Abdominal crests with white hairs and papillae and small white processes apically.

Holotype ♀. Mt. Lewis, 1,060 m, Queensland, 20. VI. 71. Coll. R. Taylor and J. Feehan and extracted from forest-floor litter by G. F. Monteith, in A. N. I. C., Canberra.

SPECIES DESCRIBED FROM NEW ZEALAND SINCE EVANS, 1966

Myerslopia insularis Knight

N. Z. Jl. Sci. 16: 992, 1973.

Type Locality — Waimoa West, Nelson Province.

Type Location — D. S. I. R. Entomology Division, Auckland.

Myerslopia similis Knight

N. Z. Jl. Sci. 16: 994, 1973.

Type Locality — Mount Hercules, Westland Province.

Type Location — D. S. I. R. Entomology Division, Auckland.

Myerslopia montis Knight

N. Z. Jl. Sci. 16: 994, 1973.

Type Locality — Mount Stokes, Marlborough Province.

Type Location — D. S. I. R. Entomology Division, Auckland.

Myerslopia bifurcata Knight

N. Z. Jl. Sci. 16: 994, 1973.

Type Locality — Waitakere Range, Auckland Province.
Type Location — D. S. I. R. Entomology Division, Auckland.

Myerslopia townsendi Knight

N. Z. Jl. Sci. 16: 995, 1973.

Type Locality — Lake Wahapo, Auckland Province

Type Location — D. S. I. R. Entomology Division, Auckland.

Myerslopia variabilis Knight

N. Z. Jl. Sci. 16: 997, 1973.

Type Locality — Takaka Hills, Nelson Province.

Type Location — D. S. I. R. Entomology Division, Auckland.

Myerslopia aspersa Knight

N. Z. Jl. Sci. 16: 998, 1973.

Type Locality — Otaki Forks, Wellington Province.

Type Location — D. S. I. R. Entomology Division, Auckland.

Myerslopia terrestris Knight

N. Z. Jl. Sci. 16: 1000, 1973.

Type Locality — Orongorongo F.S., Wellington Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

Myerslopia verrucosa Knight

N. Z. Jl. Sci. 16: 1000, 1973.

Type Locality — Bruce Park, Hunterville, Wellington Province.

Type Location — D.S.i.R. Entomology Division, Auckland.

Myerslopia triregia Knight

N. Z. Jl. Sci. 16: 1005, 1973.

Type Locality — Three Kings Island.

Type Location — D.S.I.R. Entomology Division, Auckland.

THE ANTIQUITY OF THE MYERSLOPIINI

In several previous publications the Ulopinae[1] have been referred to as a 'relict group' (e.g. Evans, 1968). This designation has been based on a balanced consideration of morphological characteristics and distributional factors.

Their supposedly primitive structural features are as follows:

(a) The retention of subgenal sutures in the head and the situation of the maxillary sensory pits close to these sutures (Ulopini, Cephalelini, some Monteithiini).

(b) The presence of small pronotal paranota (Monteithiini, some Myerslopiini).

(c) The angulate condition of vein CuA, proximally, in the tegmen (a few Ulopini, e.g. *Coloborrhis rugosa* Evans).

(d) The bisegmented condition of the subgenital plates (some Ulopini, Cephalelini and Monteithiini).

The Myerslopiini retain only one of these supposedly primitive characteristics and, in some respects, they are the most highly specialised of all the Ulopinae. Thus, not only are subgenal sutures lacking but in some species (eg. *M. taylori*), the maxillary plates are widely exposed. Furthermore, the hind tibiae are heavily spined and in the male genitalia of *Myerslopia* spp. the ninth sternum is continuous with the basally-fused subgenital plates and also the pygophore laterally (Knight, 1973, c).

In spite of their lack of primitive features and their possession of several highly specialised ones, it is suggested, because of the very considerable differences which separate genera and because of their particular geographical occurrences, that the Myerslopiini may possibly be the most ancient of all the several extant tribes of the Ulopinae.

[1] Because of continued uncertainty as to the position of the Megophthalmini, they are here excluded from consideration.

LEDRINAE
NEW GENERA AND SPECIES DESCRIBED FROM AUSTRALIA SINCE EVANS, 1966
LEDRINI

Ezrana primitiva Evans

Pacif. Ins. 11: 735, 1969.

Type Locality — Cairns, N. Queensland.

Type Location — Australian Museum.

Platyledra caldida Evans

Pacif. Ins. 11: 736, 1969.

Type Locality — Mr. Kosciusko, New South Wales.

Type Location — Australian Museum.

NOTES ON THE LEDRINI

Petalocephala bohemani Stål.

This species, of which *Rubria ingens* (Kirkaldy) is a synonym, is the sole representative of the Oriental genus *Petelocephala* Stål to have been recorded from Australia. The allied genus *Rubria* Stål which, in Part I, was said to have an Oriental and Australian distribution is, apart from sparse representation in New Guinea, apparently confined to Australia. A Key defining the characteristics of these genera has been given (Evans, 1969, b).

THYMBRINI

Putoniessiella Evans

Pacif. Ins. 11: 746, 1969.

Type species — *Putoniessiella sagitta* Evans.

Putoniessiella sagitta Evans

Pacif. Ins. 11: 746, 1969.

Type Locality — Tammin, Western Australia.

Type Location — British Museum.

Thymbrella Evans

Pacif. Ins. 11: 747, 1969.

Type species — *Thymbrella tamminensis* Evans

Thymbrella tamminensis Evans

Pacif. Ins. 11: 747, 1969.

Type Locality — Tammin, Western Australia.

Type Location — British Museum.

Microledrella Evans

Pacif. Ins. 11: 745, 1969.

Type species — *Microledrella minuta* Evans.

This genus is seemingly closely related to the genera *Ledrella* Evans and *Novothymbris* Evans and, like them, may lie close to the base of the thymbrid stem.

Microledrella minuta Evans

Pacif. Ins. 11: 745, 1969.

Type locality — Wissel Lakes, N.W. New Guinea.

Type Location — Bishop Museum.

Macroceps moorei Evans

Pacif. Ins. 11: 746, 1969.

Type Locality — Yanchep, Western Australia.

Type Location — Australian Museum.

Epipychidion fides Evans

Pacif. Ins. 11: 749, 1969.

Type Locality — Berowra Waters, New South Wales.

Type Location — Australian Museum.

Epipychidion whitteni Evans

Pacif. Ins. 11: 749, 1969.

Type Locality — Bruni Island, Tasmania.

Type Location — Australian Museum.

Putoniessa turneri Evans

Pacif. Ins. 11: 749, 1969.

Type Locality — Yanchep, Western Australia.

Type Location — British Museum.

Hackeriana elangatula Evans

Pacif. Ins. 11:749, 1969.

Type Locality — King George's Sound, Western Australia.

Type Location — British Museum.

SPECIES DESCRIBED FROM NEW ZEALAND SINCE EVANS, 1966

Novothymbris notata Knight

N. Z. Jl. Zool. 1: 457, 1974.

Type Locality — Whangarei, Auckland Province.

Type Location — British Museum.

Novothymbris punctata Knight

N. Z. Jl. Zool. 1: 458, 1974.

Type Locality — Wellington, Wellington Province.

Type Location — D. S. I. R. Entomology Division, Auckland.

Novothymbris tararua Knight

N. Z. Jl. Zool. 1: 459, 1974.

Type Locality — Tararua Range, Mt. Alpha, Wellington Province.

Type Location — British Museum.

Novothymbris peregrina Knight

N. Z. Jl. Zool. 1: 462, 1974.

Type Locality — Eglinton Valley, Otago Province.

Type Location — D. S. I. R. Entomology Division, Auckland.

Novothymbris cithara Knight

N. Z. Jl. Zool. 1: 460, 1974.

Type Locality — Westport, Nelson Province.

Type Location — D. S. I. R. Entomology Division, Auckland.

Novothymbris vagans Knight

N. Z. Jl. Zool. 1: 462, 1974.

Type Locality — Hunter Mountain, Otago Province.

Type Location — D. S. I. R. Entomology Division, Auckland.

Novothymbris notialis Knight

N. Z. Jl. Zool. 1: 463, 1974.

Type Locality — Mt. Rakeahua, Stewart Island.

Type Location — D. S. I. R. Entomology Division, Auckland.

Novothymbris castor Knight

N. Z. Jl. Zool. 1: 464, 1974.

Type Locality — L. Mahinerangi, Otago Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

Novothymbris pollux Knight

N. Z. Jl. Zool. 1: 466, 1974.

Type Locality — McLennan's Bush, Canterbury Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

Novothymbris eylesi Knight

N. Z. Jl. Zool. 1: 468, 1974.

Type Locality — Mt. Snowflake, Marlborough Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

Novothymbris extremitatas Knight

N. Z. Jl. Zool. 1: 470, 1974.

Type Locality — Spirits Bay, Auckland Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

Novothymbris solitaria Knight

N. Z. Jl. Zool. 1: 471, 1974.

Type Locality — Awatotara, Chatham I.

Type Location — D.S.I.R. Entomology Division, Auckland.

NOTES ON THE THYMBRINI

Hackeriana Evans

In Part I (p. 128), it was stated that this genus superficially resembled *Neotartessus* gen. nov. This was an error caused by the use of a manuscript name which should be replaced by *Stenotartessus* Evans.

Novothymbris spp.

N. dunensis (Myers) has been placed in synonymy with *N. hinemoa* (Myers) and *N. hudsonensis* (Myers) with *N. maorica* (Myers), (Knight, 1974, a).

HECALINAE
A NEW GENUS AND NEW SPECIES DESCRIBED FROM AUSTRALIA SINCE EVANS, 1966
HECALINI

Micrelloides Evans

Pacif. Ins. 15: 189, 1973.

Type species — *Micrelloides molaris* Evans.

Micrelloides molaris Evans

Pacif. Ins. 15: 189, 1973.

Type Locality — Millstream area, Western Australia.

Type Location — Australian Museum.

SPECIES DESCRIBED FROM NEW ZEALAND SINCE EVANS, 1966
PARADORYDIINI

Paradorydium sertum Knight

N.Z.Jl. Sci. 16: 966, 1973.

Type Locality — Mount Coronet, Queenstown.

Type Location — D.S.I.R. Entomology Division, Auckland.

Paradorydium aculeatum Knight

N.Z.Jl. Sc. 16: 966, 1973.

Type Locality — Mount Bitterness, Otago Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

Paradorydium watti Knight

N.Z.Jl. Sc. 16: 967, 1973.

Type Locality — Awatere Valley, Marlborough Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

Paradorydium cuspis Knight

N.Z.Jl. Sc. 16: 968, 1973.

Type Locality — Mt Arthur, Nelson Province.

Type Location — British Museum.

Paradorydium narrabrensis sp. n.
(Fig. 10)

Length, ♀, 7.7 mm; of crown, 2 mm. Dorsal surface, pale straw colour. Head spatulate, slightly curving upwards apically. Face, frontoclypeus convex, tapering posteriorly; vertex, concave apically. Crown and pronotum punctate, the coronal suture forming a low ridge. Tegmen pale hyaline brown; veins pale brown, prominent; clavus punctate. Holotype ♀,

Waiwera, Narrabri, N. S. W., 4-XI-74, P. M. Room, on cotton, in the A. N. I. C., Canberra. One Paratype, sex unknown, in author's collection. *P. narrabrensis* differs, in the shape of the head, from all other described species of *Paradorydium* Kirkaldy.

NOTES ON THE PARADORYDIINI

Paradorydium stewartensis Evans has been placed in synonymy with *P. philpottii* Myers. It has been noted that the type locality is Stephens Island and not Stewart Island as previously recorded and that the holotype of *P. gourlayi* is a female and not a male insect (Knight, 1973, b).

APHRODINAE

Kosmiopelix Kirkaldy: *Euacanthella* Evans

The above genera were assigned to this subfamily in Part I. Recently, it has been shown that neither have close affinity with *Aphrodes* Curtis.

Kosmiopelix has been placed in synonymy with *Chiasmus* Mulsant and Rey (Deltocephalinae) and *Euacanthella* assigned to a new subfamily, the Euacanthellinae. In addition, *Euacanthella brunnea* Evans, described from New Zealand, has been shown to be a synonym of the Australian species, *E. palustris* Evans and *E. bicolor* Evans, formerly regarded as a synonym of *E. palustris*, has been reinstated as a separate species (Evans, 1974).

The Aphrodinae, accordingly, may be assumed to lack representation in both Australia and New Zealand.

Fig. 10. *Paradorydium narrabrensis*

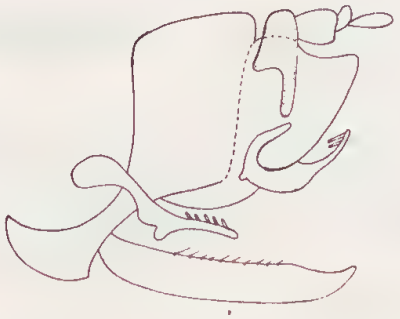

Fig. 11. *Austroagalloides moorei*, male genitalia

CICADELLINAE
CICADELLINI

Tettigonia albomarginata Signoret

This species, which in Part I was tentatively referred to the genus *Kolla* Distant, has in Japan, whence it has also been recorded, been referred to the genus *Ishidaella* Matsumura. The Japanese insect differs from Australian species in being considerably smaller and in the male lacking a pale tegminal costal margin. Ishihara has suggested that Japanese specimens identified as *T. albomarginata* should more correctly be referred to as *Ishidaella atramentaria* (Motschulsky) (Ishihara, 1967, 1971).

NIRVANINAE
NIRVANINI

Pseudonirvana Baker

This genus (type species, *P. sandakanensis* Baker) is a synonym of *Sophonia* Walker (type species, *S. rufitelum* Walker) (new synonymy).

MACROPSINAE
SPECIES DESCRIBED FROM AUSTRALIA SINCE EVANS, 1966

Macropsis gearyi Evans

Pacif. Ins. 13: 355, 1971.

Type Locality — Carnarvon, Queensland.

Type Location — Australian Museum.

Macropsis bella Evans

Pacif. Ins. 13: 356, 1971.

Type Locality — Albany, Western Australia.

Type Location — Australian Museum.

Macropsis nikitini Evans

Pacif. Ins. 13: 356, 1971.

Type Locality — Warwick Farm, New South Wales.

Type Location — Australian Museum.

Macropsis emmae Evans

Pacif. Ins. 13: 357, 1971.

Type Locality — Braidwood, New South Wales.

Type Location — Australian Museum.

Macropsis bunyensis Evans

Pacif. Ins. 13: 358, 1971.

Type Locality — Bunya Mts., Queensland.

Type Location — Australian Museum.

Macropsis mandurae Evans

Pacif. Ins. 13: 358, 1971.

Type Locality — Mandurah, Western Australia

Type Location — Australian Museum.

NOTES ON THE MACROPSINAE

Macropsis evansi Metcalf

The above is the correct name of the insect referred to in Part I as *M. occidentalis* Evans (Metcalf, 1966).

Macropsis fergusoni Evans

The male genitalia have been illustrated (Evans, 1971).

AGALLIINAE

It was stated in Part I that this subfamily was represented in New Guinea. It would seem, however, that the sole species to occur in the island is *Austroagallia torrida* Evans. This species, which is widespread in Australia, where presumably it is an introduction, is a vector of rugose leaf curl of clover (Neilson, 1968; Evans, 1971).

AUSTROAGALLOIDINAE

Austroagalloides moorei sp. n.
(Fig. 11)

Length, ♂, 6 mm; ♀, 6.8-7 mm. Overall coloration, bright yellow. Crown of head, bearing the ocelli, transversely convex and steeply declivous. Lateral muscle impressions on scutellum, mottled brown. Male genitalia as in Fig. 11.

Holotype ♂and Allotype ♀, Ord River Diversion Dam, Western Australia, VII-74, K. M. Moore, in the Australian Museum. Other localities, Eldo, 8 miles S. of Gove Airport, N. T.; Darwin, N. T.; Marginup, W. A.

A. moorei differs from other described species of *Austroagalloides* in its distinctive coloration. While its male genitalia are similar to those of *A. brunneus* Evans in general features, they differ in the shape of the ventral extension of the tenth abdominal segment and of the median dorsal section of the aedeagus. Moreover, unlike *A. brunneus, A. moorei* is not sexually dimorphic.

NOTES ON THE AUSTROAGALLOIDINAE SUGGESTED AFFINITIES WITH THE EURYMELIDAE

In a recent paper it has been suggested that the Austroagalloidinae are related to the Eurymelidae (Davis, 1975). This opinion is based on a comparative study of the female genitalia and the metathoracic legs of representatives of these, and of a few other, selected groups of leafhoppers.

Other, supposedly more significant, structural features lend no support to this suggestion. These features in respect to both groups were described and illustrated in Part I.

IDIOCERINAE
NEW RECORD FROM NEW ZEALAND

Idiocerus decimquartus (Schrank)

This insect, which is widely distributed in the Holarctic region, has become established in New Zealand (Knight, 1974, b).

TARTESSINAE

The Tartessinae are of unusual interest in being the sole group of leafhoppers occurring in Australia to have become adapted to both xerophytic and tropical rain forest conditions. Their ability to colonise the last named environment has enabled their northward extension into New Guinea and the Oriental region where prolific speciation has taken place. Currently the group is being studied by F. Evans.

Tartessoides griseus Evans

The holotype is a male, and not a female insect, as stated in the original description (Evans, 1937, b). The heads of the latter sex, unlike those of the males, are narrowly produced (Evans, 1975). A new locality record for this species is Simpson's Gap, Northern Territory.

JASSINAE
JASSINI
SPECIES DESCRIBED FROM AUSTRALIA SINCE EVANS, 1966

Batracomorphus brooksi Evans

Pacif. Ins. 14: 654, 1972.

Type Locality — Kuranda, N. Queensland.

Type Location — Australian Museum.

Batracomorphus samii Evans

Pacif. Ins. 14: 655, 1972.

Type Locality — Cairns, N. Queensland.

Type Location — Australian Museum.

Batracomorphus fasciatus Evans

Pacif. Ins. 14: 655, 1972.

Type Locality — Cairns, N. Queensland.

Type Location — Australian Museum.

NOTES ON THE JASSINI

Batracomorphus Lewis

In Part I this generic name was given throughout, incorrectly, as *Batrachomorphus*. The correct reference to the original description is Trans. Ent. Soc. Lond. 1836, 1: 51, and not as shown in Part I (p. 203)

Batracomorphus sontiates (Kirkaldy)

The male genitalia have been illustrated (Evans, 1972, b).

Batracomorphus angustatus (Osborn)

This Western Pacific species has been recorded from New Zealand (Knight, 1974, b).

PENTHIMIINAE
A NEW GENUS AND NEW SPECIES DESCRIBED FROM AUSTRALIA SINCE EVANS, 1966

Tomaloides Evans

Pacif. Ins. 14: 177, 1972.

Type species — *Tomaloides shepherdi* Evans

Tomaloides shepherdi Evans

Pacif. Ins. 14: 178, 1972.

Type Locality — Broken Hill, New South Wales.

Type Location — Australian Museum.

Chinaella pingellensis Evans

Pacif. Ins. 14: 176, 1972.

Type Locality — Pingelly, S.W. Australia.

Type Location — Australian Museum.

Platyscopus moorei Evans

Pacif. Ins. 14: 196, 1972.

Type Locality — Coolgardie, Western Australia.

Type Location — Australian Museum.

NOTES ON THE PENTHIMIINAE

In a recent review of this subfamily several changes in nomenclature were made (Evans, 1972, a). These are as follows: —

The following species referred in Part I to the genus *Neodartus* Melichar have been transferred to *Vulturnus* Kirkaldy; *brunneus* (Evans), *lapsus* (Evans), *maculosus* (Evans) and *pallidus* (Evans). The species originally described as *Thaumatoscopus dunkenis* Evans has also now been referred to this genus.

The following species referred, in Part I, to *Vulturnus* Kirkaldy have been transferred to *Neovulturnus* Evans: *vaecors* (Kirkaldy), *vanduzeei* (Kirkaldy) (incorrectly given as *vanduzei* in Part I), *vaedulcis* (Kirkaldy), *vappa* (Kirkaldy), *vultuosus* (Kirkaldy), *hackeri* (Evans), *montanus* (Evans), *punctulatus* (Evans), *sordidus* (Evans).

As the genus *Vulturnellus* Evans has been shown to be a synonym of *Neodartus* the

species described in Part I as *Vulturnellus shephardi* becomes *Neodartus shephardi* (Evans, 1972, a).

Ectopiocephalus vanduzeei Kirkaldy

This name was incorrectly given in Part I as *E. vanduzei*.

DRABESCINAE
A NEW SPECIES DESCRIBED FROM AUSTRALIA SINCE EVANS, 1966

Drabescus palmerstoni Evans

Pacif. Ins. 14: 199, 1972.

Type Locality — Palmerston National Park, Queensland.

Type Location — Queensland Museum.

NOTES ON THE DRABESCINAE

A reference given to a paper in Part I (p.220), relating to this subfamily, should have been accompanied by the date 1953, not 1951.

DELTOCEPHALINAE
NEW GENERA AND NEW SPECIES DESCRIBED FROM NEW ZEALAND SINCE EVANS, 1966
DELTOCEPHALINI[1]

Limotettix pallidus Knight

N. Z. Jl. Zool. 2: 173, 1975.

Type Locality — Tasman Valley, Canterbury Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

Limotettix condylus Knight

N. Z. Jl. Zool. 2: 175, 1975.

Type Locality — Spirits Bay, Auckland Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

Limotettix harrisi Knight

N. Z. Jl. Zool. 2: 175, 1975.

Type Locality — Ohakune, Wellington Province.

Type Location — British Museum.

Arawa Knight

N. Z. Jl. Zool. 2: 176, 1975.

Type species — *Arawa variegata* Knight.

1 See remarks in Part I, p. 222, on the recognition of the components of this tribe.

Arawa variegata Knight

N. Z. Jl. Zool. 2:178, 1975.

Type Locality — Richmond Range, Nelson Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

Arawa salubris Knight

N. Z. Jl. Zool. 2: 180, 1975.

Type Locality — Tasman Valley, Canterbury Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

Arawa dugdalei Knight

N. Z. Jl. Zool. 2: 181, 1975.

Type Locality — Altimarlock, Marlborough Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

Arawa pulchra Knight

N. Z. Jl. Zool. 2: 185, 1975.

Type Locality — Ohakune, Wellington Province.

Type Location — British Museum.

Arahura Knight

N. Z. Jl. Zool. 2: 185, 1975.

Type species — *Arahura reticulata* Knight

Arahura reticulata Knight

N. Z. Jl. Zool. 2: 186, 1975.

Type Locality — Mt. Burns, Otago Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

Arahura gourlayi Knight

N. Z. Jl. Zool. 2: 188, 1975.

Type Locality — Stephens Island.

Type Location — D.S.I.R. Entomology Division, Auckland.

Arahura dentata Knight

N. Z. Jl. Zool. 2: 189, 1975.

Type Locality — Cuvier Island.

Type Location — Auckland Museum.

Deltocephalus (Recilia) vetus Knight

N. Z. Jl. Zool. 2: 203, 1975.

Type Locality — Tasman Valley, Mt. Cook National Park, Canterbury Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

Scaphetus simus Knight

N. Z. Jl. Zool. 2: 196, 1975.

Type Locality — Nelson, Nelson Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

Horouta Knight

N. Z. Jl. Zool. 2: 205, 1975.

Type species — *Horouta inconstans* Knight

Horouta inconstans Knight

N. Z. Jl. Zool. 2: 206, 1975.

Type Locality — Mt. Cook National Park, Canterbury Province.

Type Location — D.S.I.R. Entomology Division, Auckland.

PLATYMETOPIINI

Stenogiffardia gen. nov.

The head is roundly and narrowly produced and may be upwardly curved apically and ventrally carinate. On the face, the wide maxillary plates are evenly rounded externally. The lateral sutures of the frontoclypeus diverge posteriorly and the antennal ledges are obscure. The antennae do not extend as far as the sides of the head. The ocelli are on the sides of the head adjacent to the lateral frontal sutures and close to the eyes. The pronotum, laterally, widely separates the eyes from the bases of the tegmina. The tegmina may be fully developed or reduced to small pads. In forms with fully developed tegmina M1+2 proximally of its junction with Rs, is unusually long and the appendix continues around the apex of the tegmen to the costal margin. The hind tibiae are strongly spinose.

Type species — *Stenogiffardia elongata* sp. n.

Stenogiffardia resembles *Giffardia* Kirkaldy (Fig. 12D-F) in having a narrowly produced head and in the female, the abdomen extending well beyond the apices of the folded tegmina. It differs in having a considerably longer head; in the crown being transversely convex and not dorsally flattened and, in antennal length.

Stenogiffardia elongata sp. n.
(Fig. 12A-C)

Length, brachypterous ♀, 8.6 mm; fully winged ♀, 7 mm; of head, 2.2; 2 mm. General coloration, pale yellowish-brown. Apex of crown of head, medially depressed, laterally carinate. Tegminal pads in brachypterous forms, dull yellowish-brown; tegmina of fully winged forms, vitreous. Holotype, brachypterous ♀, Richmond, N. W. Queensland, 23-VIII-65, coll. T. E. Woodward, in the Queensland Museum.

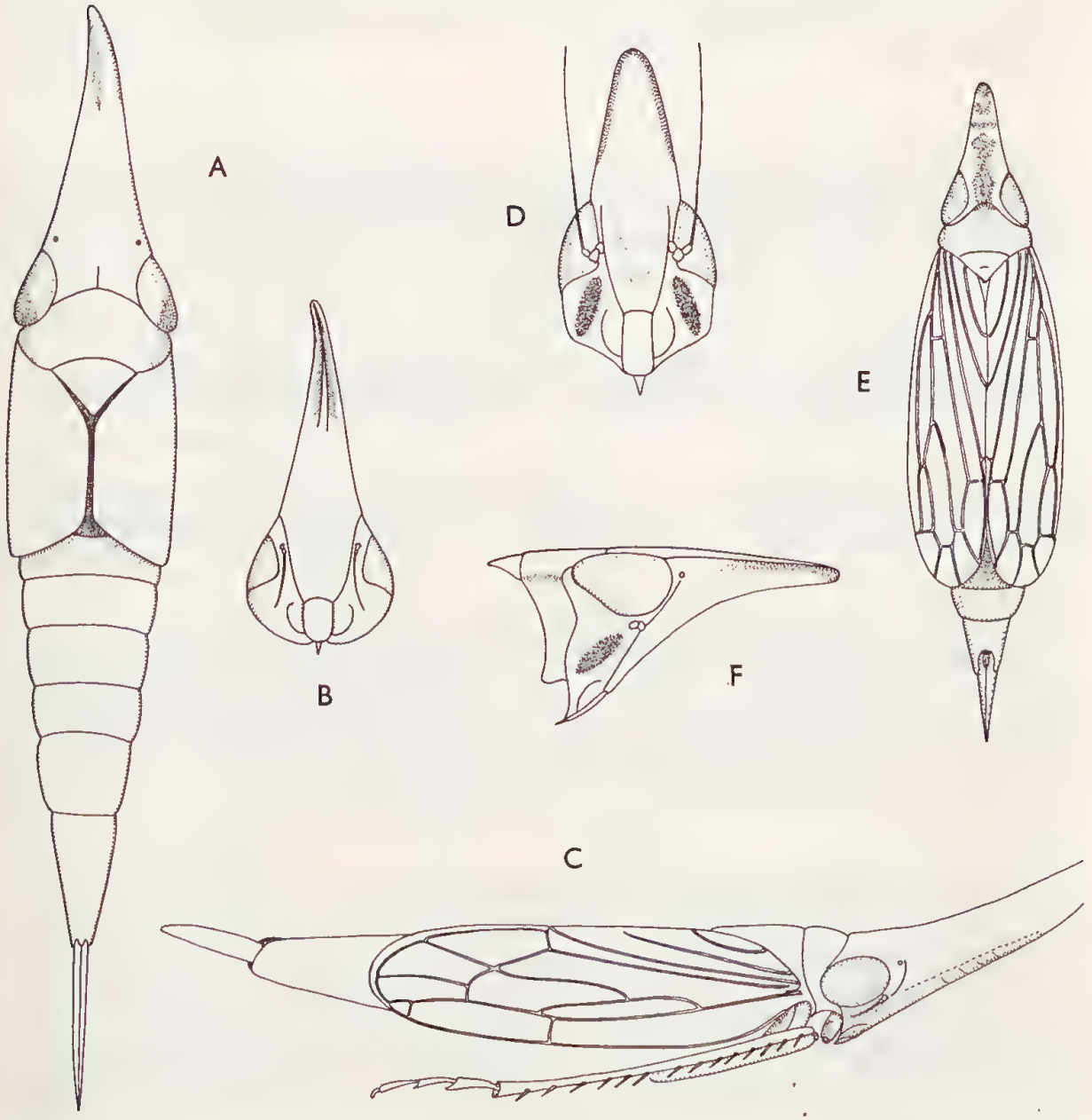

Fig. 12. *Stenogiffardia elongata*, A, brachypterous ♀; B, face of head; C, fully winged ♀. *Giffardia dolichocephala*, D, face of head; E, ♀, in dorsal aspect F, head and thorax in profile.

NOTES ON THE DELTOCEPHALINAE

Reasons for the difficulties associated with the identification of Australian Deltocephalinae have been given previously (Part I, p. 222). In the notes that follow particulars are given of changes in nomenclature and of new knowledge acquired since December, 1965.

Jassus detractus Walker (1858)

The type locality of this insect which was omitted from Part I, and which Metcalf (1964) referred to the genus *Coelidia*, is Tasmania. Dr. M. Ghauri, who has examined the holotype in the British Museum at my request, is of the opinion that it belongs to, or near, *Euscelis* Brullé.

Limotettix awae (Myers)

This insect, which was described from New Zealand by Myers (1924) as *Cicadula awae* and which has been referred to *Limotettix* by Knight (1975), was omitted from Part I.

Opsius stactogalus (Fieber)

O. stactogalus, which feeds on *Tamarisk*, and has a more or less cosmopolitan distribution, has not previously been recorded from Australia. Recently specimens were taken in a light trap in Perth, Western Australia.

Orosius Distant

It was stated in a footnote on page 234 of Part I that this genus was being currently revised. The Revision referred to has now been published (Ghauri, 1966). More recently Linnavuori (1975), has noted that Ishihara (1963) has redescribed *Orosius argentatus* (Evans) and identified it as *Eutettix orientalis* Matsumura (1914). As there is, however, some doubt as to whether the Australian and Japanese insects are truly conspecific, the name *O. argentatus* for the time being is best retained.

Exitianus Ball

This genus has recently been revised by Ross (1968). As a result some changes in nomenclature need to be noted.

Since it is impossible to associate the female holotype of *Athysanus capicola* Stål with any species recognized on male genitalia characteristics, the insect referred to in Part I as *Exitianus capicola* Stål should be known as *E. plebeius* (Kirkaldy). It is possible that *E. pallida* (Evans) and *E. selbyi* (Evans), of which the types likewise are females, may be synonyms of *E. plebeius*. It was stated in Part I that the type of *E. pallida* was in the Australian Museum, whereas, in fact, it is in the South Australian Museum.

According to Ross neither *Nephotettix contemptus* Kirkaldy nor *N. eurytus* Kirkaldy, which in Part I, were referred to *Exitianus*, belong to this genus. It is possible they belong to *Hybrasil* Kirkaldy (type species: *H. brani* Kirkaldy), as may also the insect recorded in Part I as *Carvaka fulvida* Evans.

Nephotettix apicalis (Motschulsky)

Recently Ghauri (1971) stated that the correct name of the insect recorded as above in Part I was *Nephotettix nigropictus* (Stål). Subsequently, following an examination of Motschulsky's types, Vilbaste (1975), has sunk this specific name as a synonym of *Nephotettix nigromaculatus* (Motschulsky).

Phrynophyes Kirkaldy: *Campbellinella* Distant.

According to Vilbaste (1965) the above genera are synonyms of *Aconura* Lethierry. The same author has suggested that *Aconura fatigandus* (Kirkaldy), referred to in Part I as *Campbellinella fatigandus,* may be a synonym of *Aconura grandis* Matsumura (1914), also that *Anemochrea* Kirkaldy may likewise be a synonym of *Aconura* (personal communication, 1975).

Hishimonus Ishihara

In Part I *Eutettix passiflorae* Evans was placed in synonymy with *Hishimonus disciguttus* (Walker). According to Knight (1970, b) the last named species does not belong to the genus *Hishimonus* and he has referred it to a new genus *Litura* Knight, which, apparently, is not represented in Australia. Accordingly, the current name of the insect referred to in Part I as *Hishimonus disciguttus* is *H. passiflorae* (Evans) (Knight, 1970, a).

Deltocephalus Burmeister: *Limotettix* Sahlberg

In the opinion of Dr. J. Vilbaste (personal communication, 1975) none of the Australian and New Zealand leafhoppers ascribed to the above genera truly belong to them.

Deltocephalus montanus Evans

Knight (1975) has referred this species, which Metcalf (1967), had given the new specific name *novellus,* to the genus *Arawa.*

Deltocephalus taedius (Kirkaldy)

The type locality is Bundaberg, Queensland, and not as recorded in Part I. Knight (1975), has expressed the opinion that the insect recognized in Part I as *D. taedius* is, in fact, *Arawa variegata* Knight.

Deltocephalus coronifer Marshall

The insect associated with this name in Part I is probably *Recilia distincta* Motschulsky (J. Vilbaste, personal communication, 1975).

Deltocephalus pullatus Evans

Knight (1975) has stated that the above species, which is known only from female specimens, is externally identical with *Limotettix condylus* Knight, described from New Zealand.

Recilia dorsalis (Motschulsky)

This species, which in Part I was tentatively referred to the genus *Deltocephalus,* has been placed by Neilson in *Recilia* Edwards. It is known as a vector of a virus disease of rice (Neilson, 1968).

Alodeltocephalus longuinquus (Kirkaldy): *A. obliquus* Evans.

The type locality of *A. longuinquus* is Sydney, N.S.W., and not as given in Part I. According to Knight (1975), *A. obliquus* is not identical with *A. longuinquus* but a separate species. The same author has pointed out that the illustrations ascribed in Part I to *A. longuinquus* (Fig. 36J, K), are in fact, those of *A. obliquus*

Lonatura austrina Kirkaldy

Dr. J. Kramer (personal communication, 1972) is of the opinion that this species is incorrectly placed in *Lonatura* Osborn and Ball.

Giffardia dolichocephala Kirkaldy (Fig. 12D-F)

Until recently this species has been recorded only from the Cairns district of North Queensland. In the Bishop Museum collection there is a specimen from the Cyclops Mountains, West Sentani, New Guinea.

Balclutha phryne (Kirkaldy): *B. chloe* (Kirkaldy)

The above species belong to the genus *Nesoclutha* Evans, of which *Irinula* Ribaut is a synonym[1].

Balclutha incisa Matsumura

Balclutha hebe (Kirkaldy) and *B. hospes* (Kirkaldy) are both synonyms of the above[1].

Balclutha rubrostriata Melichar

Balclutha aurantiigera (Kirkaldy), *B. sanguinescens* (Kirkaldy) and *B. sordidor* (Kirkaldy) are synonyms of *B. rubrostriata*[1].

Balclutha dryas (Kirkaldy)

Probably a synonym of *Balclutha frontalis* (Ferrari)[1].

Balclutha glauca (Kirkaldy)

Probably a synonym of *B. saltuella* (Kirkaldy)[1].

Nesoclutha pallida (Evans)

This species, of which *N. obscura* Evans is a synonym, has been recorded from New Zealand (Knight, 1975). It is a vector of striate mosaic virus of grasses and cereals (Neilson, 1968).

Macrosteles fieberi (Edwards)

This Holarctic species has been recorded from New Zealand (Knight, 1975).

Limotettix capitata Kirkaldy

In Part I, *Cicadulina bipunctella* Matsumura and *C. bimaculata* Evans were placed in synonymy with the above species which consequently was referred to as *Cicadulina capitata*. It has subsequently been shown that neither of the first two mentioned species are congeneric with the third, which also does not belong to *Cicadulina* China (Kitching, Grylls and Waterford, 1973). For the time being the true generic position of *L. capitata* must remain uncertain.

In a review of the genus *Cicadulina* Zetterstedt, Ruppel (1965) has placed *C. bimaculata* as a subspecies of *C. bipunctella*. Kitching, Grylls and Waterford, however, recognize each as a separate species, populations of the former occurring in Queensland and of the latter, within Australia, in the Northern Territory. Both species have been recorded as virus vectors by the same authors.

1 Personal communication, Dr. J. Vilbaste, 1975.

TYPHLOCYBINAE
A NEW GENUS AND NEW SPECIES DESCRIBED FROM AUSTRALIA SINCE EVANS, 1966

Dziwneono Dworakowska

Bull. Acad. pol. Sci. Cl. II Ser. Sci. biol., 20: 197, 1972.

Type species — *Dwizneono etcetera* Dworakowska.

Dwizneono etcetera Dworakowska

Bull. Acad. pol. Sci. Cl. II Ser. Sci. biol., 20: 200, 1972.

Type Locality — Darwin, Northern Territory.

Type Location — Australian Museum.

Dziwneono olszewskii Dworakowska

Bull. Acad. pol. Sci. Cl. II Ser. Sci. biol., 20: 199, 1972.

Type Locality — Darwin, Northern Territory.

Type Location — Australian Museum.

Dziwneono septembris Dworakowska

Bull. Acad. pol. Sci. Cl. II Ser. Sci. biol., 20: 199, 1972.

Type Locality — Darwin, Northern Territory.

Type Location — Australian Museum.

Empoascanara australensis Dworakowska

Bull. Acad. pol. Sci. Cl. II Ser. Sci. biol., 20: 772, 1972.

Type Locality — Darwin, Northern Territory.

Type Location — Australian Museum.

Kahaono kirkaldyi Dworakowska

Bull. Acad. pol. Sci. Cl. II Ser. Sci. biol., 20: 197, 1972.

Type Locality — Darwin, Northern Territory.

Type Location — Australian Museum.

Kahaono yhawhoa Dworakowska

Bull. Acad. pol. Sci. Cl. II Ser. Sci. biol., 20: 197, 1972.

Type Locality — Albany, Western Australia.

Type Location — Australian Museum.

Kahaono yarama Dworakowska

Bull. Acad. pol. Sci. Cl. II Ser. Sci. biol., 20: 196, 1972.

Type Locality — Albany, Western Australia.

Type Location — Australian Museum.

Kahaono negrea Dworakowska

Bull. Acad. pol. Sci. Cl. II Ser. Sci. biol., 20: 197, 1972.

Type Locality — Albany, Western Australia.

Type Location — Australian Museum.

Aneono leichardti Dworakowska

Bull. Acad. pol. Sci. Cl. II Ser. Sci. biol., 20: 193, 1972.

Type Locality — Albany, Western Australia

Type Location — Australian Museum.

Aneono evansi Dworakowska

Bull. Acad. pol. Sci. Cl. II Ser. Sci. biol., 20: 193, 1972.

Type Locality — Perth, Western Australia.

Type Location — Australian Museum.

NOTES ON THE TYPHLOCYBINAE

Austroasca Lower

In Part I, this genus was placed in synonymy with *Empoasca* Walsh. Ghauri (1967), who has re-established the separate identity of *Austroasca* (type species, *Empoasca viridigrisea Paoli*), has pointed out that the genus, as at present constituted, is a heterogeneous one and in need of revision. In the same paper he has transferred *Austroasca terraereginae* (Paoli) to *Amrasca* Ghauri, type species *A. splendens* Ghauri (India).

The New Zealand typhlocybine fauna has recently been reviewed by Knight (1976, N.Z. J Zool. 3:71-87).

MEMBRACIDAE
A NEW SPECIES DESCRIBED FROM AUSTRALIA SINCE EVANS, 1966

Ceraon pix Kitching

J. Aust. ent. Soc. 14: 345, 1975.

Type Locality — Cornwall, Australia (supposedly Tasmania).

Type Location — British Museum.

NOTES ON THE MEMBRACIDAE

Ceraon contractum (Walker)

This specific name which in Part I was regarded as a synonym of *C. tasmaniae* (Fairmaire), has recently been recognized as representing a distinct species (Kitching, 1975). It differs from other species comprised in *Ceraon* Buckton in having a slender, anterior, vertical pronotal process.

Eufrenchia falcata (Walker)

In Part I a reference to an illustration of this species (Fig. 6C) was omitted.

Ceraon gracilis Goding

It was stated, in Part I, that the whereabouts of the holotype of this species was unknown and that it was not in the U. S. National Museum. I am advised by Dr. R Kitching that this was an error as the type, in fact, is in this museum.

Sextius virescens (Fairmaire)

The nymphal stages have been described (Kitching, 1974, a), also the morphology and the mode of action of the anal apparatus of the nymphs (Kitching, 1974, b).

Acanthucus trispinifer (Fairmaire)

This widely distributed Australian species has become established in New Zealand (Eyles, 1971).

CERCOPOIDEA
MACHAEROTIDAE
A NEW SPECIES DESCRIBED FROM AUSTRALIA SINCE EVANS, 1966

Chaetophyes pulcherrima Evans

Proc. Roy. Soc. Qd. 81: 83, 1970.

Type Locality — North Stradbrooke Island, Queensland.

Type Location — Queensland Museum.

TRANSFER OF TYPES

It was stated in Part I that the types of Australian cicadelloids and cercopoids described by G.W Kirkaldy were in the collection of the Hawaiian Sugar Planters Association, in Honolulu. These have now been transferred to the Bishop Museum.

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REVISION OF AUSTRALIAN SPECIES OF RISSOELLIDAE (MOLLUSCA)

W. F. PONDER AND E. K. YOO

A NEW FAMILY OF ASTEROIDEA (ECHINODERMATA)

F. W. E. ROWE

THE STATUS OF ANDORA (ASTEROIDEA)

F. W. E. ROWE

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A REVISION OF THE AUSTRALIAN SPECIES OF THE RISSOELLIDAE. (MOLLUSCA: GASTROPODA)

W. F. PONDER AND E. K. YOO

The Australian Museum, Sydney

SUMMARY

The Rissoellidae is tentatively included in the Heterogastropoda. The 14 Australian species and subspecies of *Rissoella*, 11 of which are new, are separated into 4 subgenera. Their known distributions, radulae and opercula, and in some cases the external features of the animal, are described. A key to the Australian species is given.

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INTRODUCTION

The family Rissoellidae consists of small, rather featureless gastropods found living mainly on algae in the lower littoral and shallow sublittoral zones throughout the world. It is in general, a poorly known group and contains only one genus. The anatomy of only 2 species has been described (Fretter, 1948) and the radulae of a few species have been described by Thiele (1912, 1925), Sars (1878), Troschel (1858) and Robertson (1961) but only the New Zealand fauna has been fully investigated (Ponder, 1966, 1968). Robertson (1961, 1962) has listed the taxa included in the Rissoellidae and discussed the generic units involved.

The two British species studied by Fretter (1948) were shown to have two pairs of tentacles, brightly pigmented spots on the mantle area and no ctenidium. They are hermaphroditic and a few adults survive the winter and produce hemispherical egg capsules from which emerge the crawling young, there being no pelagic larval stage. They feed on micro-algae and detritus and have a simple alimentary canal.

Records of The Australian Museum, 1977, **Vol. 31 No. 4**, 133-185, Figures 1-14.

The anatomical peculiarities of the rissoellids were attributed to their minute size by Fretter (1948) who retained them in the Rissoacea. Fretter and Graham (1954) implied that *Rissoella* has opisthobranch rather than prosobranch affinities but later Fretter (1956) and Fretter and Graham (1962) again gave *Rissoella* prosobranch status. Other authors have included the Rissoellidae in the Rissoacea (Prosobranchia) except Nordsieck (1972), who includes it in his 'superfamily' Microrissoidea (not based on a genus or family taxon and therefore unavailable) and Golikov and Starobogatov (1975) who erect a new 'suborder' Rissoellina within the Prosobranchia. Robertson (1961) does not commit himself as to their likely affinities.

The Rissoellidae shows a number of characters atypical of prosobranchs. These include the lack of an osphradium, a ctenidium and oesophageal glands or crystalline style, their hermaphrodite condition, the possession of a pigmented hypobranchial gland, the eyes placed in a median position on the tentacles, two pairs of head tentacles, the invasion of the mantle roof by the renal organ, the peculiar radula and operculum and their possible euthyneurous condition (Fretter and Graham, 1962: 313).

Although several of the above characters are more typical of the Opisthobranchia we are reluctant to include the Rissoellidae in that group because of the several prosobranch-like characters it possesses such as the simple shell, non-heterostrophic protoconch, the simple foot, the rather prosobranch-like reproductive system (despite the hermaphrodite condition) and egg capsules.

It is quite probable that *Rissoella* is a neotenous group and, consequently, some of its features may be juvenile characteristics (the two pairs of head tentacles are a possible example). If this were the case some of the prosobranch features could also be explained in this way — e.g. the simple shell, relatively spaceous mantle cavity and the simple foot.

Climo (1975) has recently outlined the characteristics of some families of the Heterogastropoda, a group which shows mixed opisthobranch and prosobranch characters. The Rissoellidae could, tentatively, be included in the Heterogastropoda although this must be considered to be a location of convenience only. A more detailed examination of the higher classification of the Rissoellidae and the other family usually included in the Rissoacea which also shows opisthobranch affinities, the Omalogyridae, is long overdue but should await anatomical information on some of the other families that are doubtful inclusions in the Rissoacea. Families such as the Trachysmidae and Trochaclisidae fall into this category. The recent radical changes in the regrouping of these families by Golikov and Starobogatov (1975) are done, in most cases, without demonstrating any supporting evidence.

The Australian Rissoellidae is comparatively rich in species, 14 species and subspecies being recognised in this revision and, undoubtedly, additional species will be added. The Australian fauna can be split into 4 subgenera within the genus *Rissoella*, 2 of which have a world-wide distribution (*Rissoella* s.s., *Jeffreysilla*), one appears to be confined to Australia, the South Pacific, New Zealand, the Subantarctic and Antarctic (*Jeffreysiella*), and the other is confined to New Zealand and southern Australia (*Zelaxitas*).

ABBREVIATIONS

A.M. ..... Australian Museum, Sydney.
coll. ..... collected by.
Coll. ..... collection.
N.M.V. ..... National Museum of Victoria, Melbourne.
N.S.W. ..... New South Wales.

Qld ..... Queensland.
Q.M. ..... Queensland Museum, Brisbane.
S.A. ..... South Australia.
S.A.M. ..... South Australian Museum, Adelaide.
S.E.M. ..... Scanning Electron Microscope.
sev ..... several.
S.W.A. ..... South Western Australia.
Tasm. ..... Tasmania.
T.M. ..... Tasmanian Museum, Hobart.
Vic. ..... Victoria.
W.A. ..... Western Australia.
W.A.M. ..... Western Australian Museum, Perth.
w ..... used in 'material examined' to indicate the number of 'wet' (i.e. formalin preserved) specimens.

Note: In the locality data, and sometimes elsewhere, compass points (north, south etc.) are abbreviated to N., S. etc.

MATERIAL AND METHODS

Most of the specimens used in this study were obtained from littoral or sublittoral samples washed from algae or from beneath stones. These were usually fixed in 10% neutral formalin and later preserved in 5% neutral formalin and/or dried. The samples were sorted beneath a stereo-microscope and the species initially separated mostly on shell characters. The animal was removed from specimens selected for radular examination, or, if this was not possible the shells were crushed to obtain the animal. Their radulae, which were obtained by macerating in concentrated, warm NaOH, were washed thoroughly in distilled water. These were mounted wet onto a piece of microscope-slide cover slip and this was fixed to a S.E.M. stub by double sided tape. The radula dried onto the glass with sufficient tenacity so that no additional adhesive was required. The operculum of each specimen was also mounted in the same way or directly on the double-sided tape. A shell was selected that best matched the one(s) crushed and this was mounted on the double-sided tape on the same stub as the radula and operculum. In many cases more than one radula and operculum were examined from one population. The specimens were coated, usually with gold, and examined and photographed with the scanning electron microscope (S.E.M.).

The S.E.M. stubs were given registered numbers (S.E.M. stub no.) and these are referred to in the text. All of this material is housed in the Australian Museum.

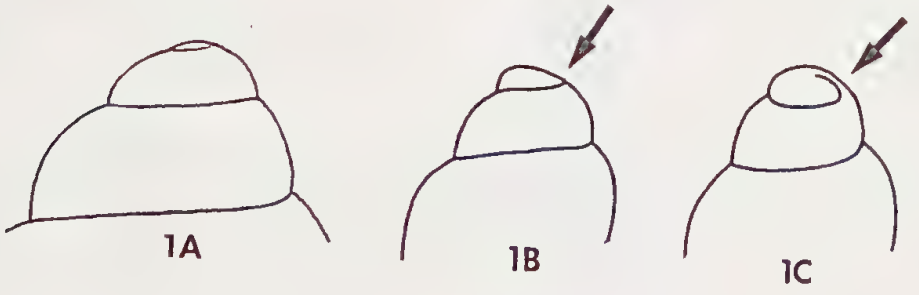
The coverage of the material available is such that most of the common shallow water species from the east, south and west coasts, and Tasmania have probably been encountered but, no doubt, additional species will be discovered with more extensive sampling. A few suitable samples were available from the north coast but no rissoellids were obtained.

Most of the material included in this revision was collected alive. 'Dead' shells are difficult to identify except in a few cases where shape and/or colour are distinctive. The differentiating shell characters of most species are so subtle that only perfect material can be used to make a reliable identification and sometimes confirmation is necessary from an examination of the radula.

Except where it is otherwise indicated, all of the material listed under 'Additional Material Examined' is housed in the Australian Museum.

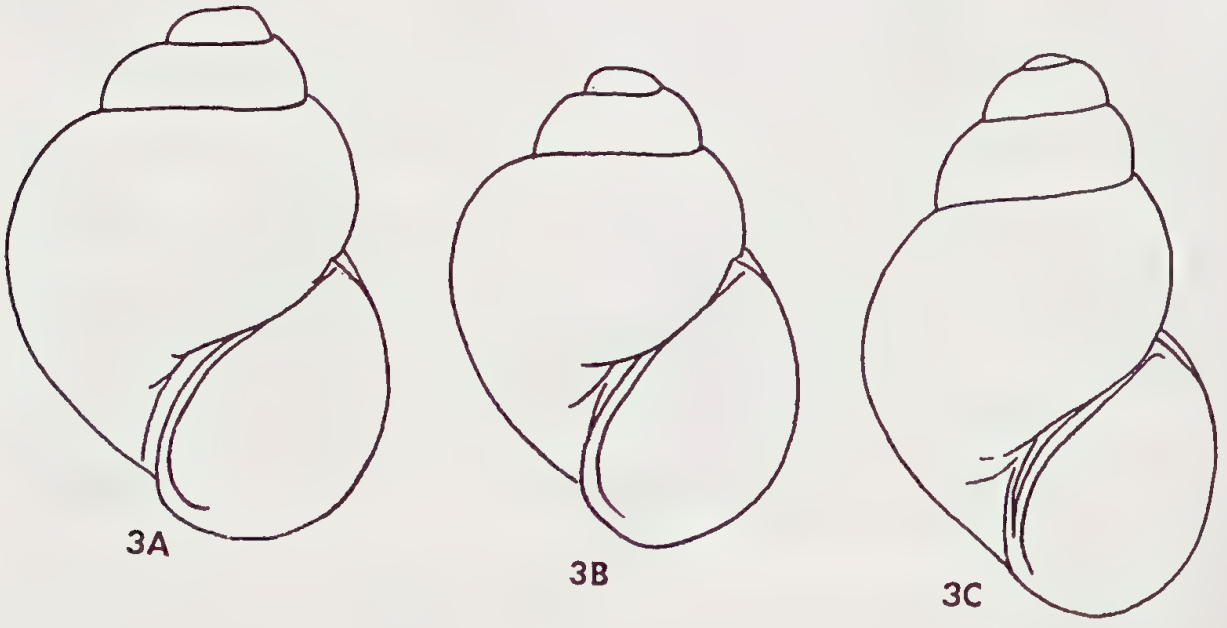
KEY TO THE AUSTRALIAN SPECIES AND SUBSPECIES OF *RISSOELLA* BASED ON SHELL CHARACTERS AND GEOGRAPHIC LOCATION

1. Spire length approximately equal to, or less than, length of aperture, protoconch evenly rounded (fig. 1A) 2
   Spire length considerably greater than length of aperture, protoconch deviated (figs 1B, C) 12



2. White or colourless 3
   Brown 11

3. Spire length usually less than length of aperture, body whorl very large and inflated (figs 3A, B) 4
   Spire length about equal to (sometimes slightly longer or shorter) length of aperture, body whorl large but not markedly inflated (fig. 3C) 6



4. Western and south Western Australia ..... *Rissoella (Rissoella) atrimacula* sp.nov.
   Tropical Pacific and eastern Australia 5
5. Spire very short, tropical eastern Australia and Pacific (fig. 3A) .....
   ..... *Rissoella (Rissoella) globosa* sp. nov.
   Spire moderately short, south eastern Australia (fig. 3B) .....
   ..... *Rissoella (Rissoella) fallax* sp. nov.
6. Umbilicus well developed, south Western Australia (fig. 6A) .....
   ..... *Rissoella (Jeffreysilla) confusa umbilicata* subsp. nov.
   Umbilicus small to moderate (fig. 6B) 7

6A 6B

7. Colourless, or white with distinct axial colourless streaks 8
   Semi-transparent to semi-opaque, uniform white 9
8. Transparent, colourless, tropical eastern Australia and Pacific .....
   ..... *Rissoella (Jeffreysilla) confusa confusa* sp. and subsp. nov.
   Transparent, colourless or white with axial colourless streaks, Western to South Australia ..... *Rissoella (Rissoella) vitrea* sp. nov.
9. Protoconch symmetrically coiled 10
   Protoconch slightly deviated, southern Australia .....
   ..... *Rissoella (Jeffreysiella) wilfredi* (Gatliff and Gabriel)
10. Protoconch raised, first half whorl clearly visible in side view, south Western Australia (fig. 10A) . *Rissoella (Jeffreysilla) confusa umbilicata* subsp. nov.
    Protoconch flattened, first half whorl largely hidden in side view, south eastern Australia (fig. 10B) .. *Rissoella (Jeffreysilla) confusa robertsoni* subsp. nov.

10A 10B

11. Umbilicate when adult, south eastern Australia and Tasmania .....
..... *Rissoella (Zelaxitas) micra* (Finlay)
Non-umbilicate when adult, Tasmania and southern Australia .....
..... *Rissoella (Zelaxitas) imperforata* sp. nov.

12. Shell greater than 1.5 mm in length 13
Shell less than 1.5 mm in length 15

13. Relatively inflated body whorl and large aperture, white, southern Australia ..... *Rissoella (Jeffreysiella) wilfredi* (Gatliff and Gabriel)
Relatively narrow body whorl and small aperture, yellowish to pinkish, western, southern and eastern Australia and Pacific 14

14. Narrow spire, western and southern Australia .....
..... *Rissoella (Jeffreysiella) fretterae* sp. nov.
Medium spire, eastern Australia and Pacific .....
..... *Rissoella (Jeffreysiella) secunda* (Iredale)

15. Colourless, transparent, south Western Australia .....
..... *Rissoella (Jeffreysiella) colleenae colleenae* sp. and subsp. nov.
White, semi-transparent, eastern Australia .....
..... *Rissoella (Jeffreysiella) colleenae pacifica* subsp. nov.

TAXONOMY

Family **Rissoellidae** M. E. Gray, 1850.

Synonym Jeffreysiadae Carpenter, 1856.

DIAGNOSIS: *Shell:* Small, thin, spire raised, whorls convex, aperture simple, peristome thin and sharp. *Radula:* Variable, a central, lateral, and 0-2 marginal teeth. *Operculum:* Approximately semicircular, the columellar edge very bluntly angled; not spirally coiled, nucleus together with a short, blunt, internal peg at apex of angle on columellar edge. *Animal:* Head with long oral lobes and cephalic tentacles; eyes in about middle of base of cephalic tentacles. Mantle with brightly pigmented spots. Mantle cavity lacks a ctenidium, respiratory currents being maintained largely by a ciliated exhalant tract which runs forward from the anus. Jaw present, oesophageal glands and crystalline style absent. Renal organ spread along much of roof of mantle cavity. Hermaphroditic; sperm and ova produced in same gland. Penis simple, folded back in a groove. Female genital system diaulic and relatively simple. Egg capsules hemispherical or ovoid, attached, with stiff outer coverings (i.e. not gelatinous) with 1-2 eggs. Development direct in the 2 species investigated (Fretter, 1948).

Genus **Rissoella** J. E. Gray 1847.

Type species (Monotypy): *Rissoa? glaber* Alder (= *Rissoella glaber* (err. pro *glabra*) J. E. Gray, 1847; = *Rissoa? diaphana* Alder, 1848; = *Rissoa albella* Alder, 1844).

Synonym *Jeffreysia* Alder, in Forbes and Hanley, 1850.

Type species (original designation): *Jeffreysia diaphana* (Alder, 1848).

DIAGNOSIS: *Shell:* Simple, thin, globose to elongate, umbilicate or non-umbilicate, usually colourless, white or brownish. Surface smooth except for very weak growth lines. Protoconch simple, of about $1\frac{1}{3}$-$1\frac{1}{2}$ whorls, sometimes apex deviated. Aperture simple, entire, with inner lip sometimes slightly thickened, outer lip thin, without a varix and never thickened. Whorls convex, body whorl usually large, often globose. *Head:* As in family diagnosis. *Operculum:* With the slightly convex columellar edge bordered on its inner side

by a sharp ridge from which arises a short, blunt peg. A short, rounded ridge arises from the base of the peg and passes across less than half of the inner surface of the operculum at right angles to the columellar edge. Outer edge simple, convex. Abapical end of operculum narrowly angled, adapical end broadly convex (all orientation taken as if operculum retracted into the apertural opening). *Radula:* Variable, 3, 5 or 7 teeth in each row. Central teeth generally large, usually with many cusps but sometimes 2 (subgenus *Jeffreysilla*). Lateral teeth large, usually with many long cusps but sometimes 1 or 2 (subgenus *Jeffreysilla*). Marginal teeth small, cuspate or simple, usually only 1 pair, second pair, if present, simple (subgenus *Jeffreysiella*).

REMARKS: Ponder (1966) summarised the characteristics of the family and of the 6 subgenera then recognised and Robertson (1961) listed all of the taxa attributed to the family Rissoellidae at that time. Robertson (1962) has outlined the complex nomenclatural history of this generic name and concluded that *Rissoella* M. E. Gray, 1850 was the valid name for this genus group. Keen (1971:372) has indicated that *Jeffreysia* Alder in Forbes and Hanley (1850) has slight precedence over *Rissoella* M. E. Gray, 1850. Keen suggests accepting *Rissoella* J. E. Gray, 1847 as a valid introduction, as accepted by Robertson (1961) but this conclusion was rejected by Robertson (1962). Robertson's reasons for rejection of the 1847 introduction of *Rissoella* were that there is 'no such name as *Rissoa? glaber,* Alder' and that it 'was published as a "synonym" (subdivision) of the genus *Odostomia*'. The first point can be overcome by allowing, as Robertson (1961) did, the type designation of *Rissoa? glaber* Alder (= *Rissoa? diaphana* Alder, 1848) by monotypy. There is no doubt that *glaber* is a misspelling of *Rissoa glabra* (Brown), as Robertson acknowledges, but Gray's (1847) interpretation of this species was that of Alder's as he even accredited it with Alder's authorship not that of Brown. Robertson has indicated that *R. glabra* (Brown) (= *Pyramis glabrus* Brown, 1827) is a pyramidellid of uncertain identity, the species described under Brown's name by Alder (1844) being renamed by Alder (1848) as *Rissoa? diaphana.* Thiele (1929), Nordsieck (1972) and other authors have used *glabra* Brown as a senior synonym of *diaphana* Alder and there is little in the original figure and description of Brown's species to suggest that they are wrong except that Brown (1844) mentions a weak fold on the columella. This observation supports Robertson's view and is the one which we also tentatively adopt. The International Code of Zoological Nomenclature (I.C.Z.N.) (1961), article 70(b) clearly indicates that in the case of a deliberate use of a misidentification by the author of a new genus, the type species is to be interpreted as the one actually before the designator, not the one that correctly bears its name. Article 70(b)(i) states that in such a case the author of the new nominal genus is considered to have established also a new nominal species with the same specific name as the misidentified species. In our view the statement '*Rissoa? glaber,* Alder' indicates an assumption by Gray of a misidentification on Alder's part. Consequently *glaber* (err. pro *glabra*) Gray, should be the type species of *Rissoella.* An earlier species name is *Rissoa albella* Alder, 1844. Whether or not both of Alder's species are the same as Brown's *glabra* will not be definitely determined unless Brown's specimens (said to be in the cabinet of General Bingham) can be located. The I.C.Z.N. (1961) Article 11(d) disallowed the availability of a name published in synonymy but this was revised in 1963 to allow names erected prior to 1961 which have been so treated to become available. The name *Rissoella* J. E. Gray, 1847 has been used by a number of authors prior to 1961. In conclusion the introduction of *Rissoella* by J. E. Gray, 1847 is considered by us to be valid.

The 4 subgenera here included in *Rissoella* are readily separated on radular characters but they are extremely difficult to define on shell features. A brief diagnosis of each subgenus is given to facilitate its recognition and for routine identification a key based on shell characters and geographical distribution is given above for all the Australian species.

Subgenus **Rissoella.**

Synonyms *Jeffreysiopsis* Thiele, 1912.

Type species (subsequent designation Robertson, 1961): *Paludestrina duperrei* Vélain, 1877.

?Jeffreysina Thiele, 1925.

Type species (subsequent designation Winckworth, 1932): *Jeffreysia globularis* ('Jeffreys' MS') Forbes and Hanley, 1852.

DIAGNOSIS: *Shell:* As in generic dignosis. *Head:* With rather long to short tentacles. *Operculum:* As in generic diagnosis. *Radula:* Central teeth large, each with convex cutting edge bearing numerous sharp cusps; lateral teeth large, each with strongly arched to almost straight cutting edge, with numerous sharp, usually large cusps. A single pair of relatively well-developed marginal teeth in each row, with few to many cusps (these probably absent in the type species of *Jeffreysina*).

REMARKS: Thiele (1925) showed that his *Jeffreysiopsis* should be regarded as a synonym of *Rissoella* s.s. because the radulae of the type species of both genus names were very similar.

Thiele (1925) noted that the radulae of *Rissoella globularis* and *R. opalina* (Jeffreys) are very similar and figured the radula of the latter. Sars (1878) gave an illustration of the radula of *R. globularis* from which Thiele (1925) suggested he omitted the finely cusped marginal teeth. Thiele indicated that the main differences between *Rissoella* and *Jeffreysina* are expressed in the differences between the radulae of the type species of each genus group name and that the shells of *Jeffreysina* are 'less high than in the other groups'. The Australian species do not, however fall neatly into either category. The shells of species showing a radula similar to that of the type species of *Rissoella* are virtually identical to those with a radula more akin to that of *Jeffreysina*. The main differences in the radulae of the type species of *Jeffreysina* and *Rissoella* are the narrow and strongly arched cutting edge of the lateral teeth and the coarsely cuspate central teeth in *Rissoella* contrasted with the broad, almost straight cutting edge of the lateral teeth and finely cuspate central teeth in *Jeffreysina*. The Australian species all show coarsely cuspate central teeth and there is a gradation between the strongly arched and the almost straight cutting edges of the lateral teeth.

The examination of a single radula of *R. globularis* suggests that Sars' (1878) interpretation was correct although our mount was a poor one. There does not appear to be any sign of marginal teeth outside the massive lateral teeth. The small central teeth are narrow and almost rudimentary. The mount was not good enough however to state positively whether or not rudimentary marginal teeth exist although it is likely that they do not. A new species described herein *(R. fallax)* has a radula with a similar form to that of *R. globularis* and *R. opalina* and has simple, plate-like marginal teeth which are possibly functionless. The loss of such teeth would give the supposed condition in *R. globularis* just as the loss of similar teeth in the subgenus *Jeffreysiella* presumably gave rise to the typical *Rissoella* pattern. On the above evidence *Jeffreysina* is here tentatively regarded as a subjective synonym of *Rissoella*.

There have not been any species of this subgenus previously recorded from Australia, although Ponder (1966) described a species from New Zealand.

Rissoella (Rissoella) atrimacula sp. nov.
Figs 1a; 3a; 4a-e

(Derivation of name: *ater*, Latin adj. — black; *macula*, Latin noun — speck or spot. Refers to appearance of living animal).

Shell: Minute, semi-transparent, globose, rather short-spired, with a distinct but narrow

umbilical chink. Protoconch of 1¼ whorls, teleoconch of 2¼ convex whorls. Inner lip of aperture slightly thickened, adapical portion not separated from parietal area by a groove. Surface smooth except for very indistinct growth lines. Colour translucent white. There is some slight variation in the height of the spire and in the size of the umbilicus in the paratype series (figs 1a; 4a, b).

Dimensions:	Length	Diameter
Holotype	1.52 mm	1.06 mm
Paratype	1.55	1.07
Figured specimens (S.E.M.)		
(paratype)	1.47	1.07
(Rottnest Is., W.A.)	1.07	0.80

Animal: Mostly black and visible through entire shell. Foot brownish-black. Head uniform black, with medium-length tentacles and oral lobes (Yallingup, S.W.A.) (fig. 3a).

Operculum: Typical (figs 4c, d).

Radula: Central teeth large, with 9-11 strong, but variable, sharp, narrow cusps on wide, curved edge. Cusps rather irregular in size. A pair of broad basal projections on each central tooth. Lateral teeth have a strong rib on inner edge of each tooth and the broad, slightly curved cutting edge has 10-12 sharp cusps. Cutting edge almost equal in width to base of tooth. Marginal teeth small, with 3 blunt, heavy, very short cusps (fig. 4e).

Opercula and radulae have been examined from the type series (S.E.M. stub no. 111), from Hopetoun Jetty, S.W.A. (S.E.M. stub no. 198) and from North Point, Rottnest Island, W.A. (S.E.M. stub no. 115).

TYPES: Holotype A.M. (C. 99655). Paratypes (46/13w) A.M. (C. 99656), 1 shell, 2 radulae and 3 opercula on S.E.M. stub no. 111. 3 W.A.M. (WAM 1376-75).

TYPE LOCALITY: Yallingup, S.W.A., on algae on limestone platform, lower shore, 2 Jan 1972, coll. W. F. Ponder and B. R. Wilson.

ADDITIONAL MATERIAL EXAMINED: Hopetoun Jetty, S.W.A., 0.5-2 m, on algae, semi-exposed and semi-sheltered reef, 5 Feb. 1972, coll. W. F. Ponder, S.E.M. stub no. 198 (sev). South Pt., S. of Two Peoples Bay, near Albany, S.W.A., on algae in large sheltered pool, on outer coast, 0-2 m, 2 Feb. 1972, coll. W. F. and J. M. Ponder (sev). Kilcarnup, N. side of Margaret River, S.W.A., on beach, 1 Jan. 1972, coll. W. F. Ponder (5). ca. 0.6 km off Peppermint Grove Beach, between Bunbury and Busselton, S.W.A., 4-7 m, in shell sand, 28 Dec. 1971, coll. W.F. and J.M. Ponder and R. Hancey (2), S.W. end of Garden Is., off Fremantle, W.A., 0.3 m, 2 lots, on algae (16); on beach (2), 21 Jan. 1972, coll. W. F. and J. M. Ponder and N. Coleman. Woodmans Pt., Cockburn Sound, W.A., 1-3 m, on sublittoral algae. 12 Dec. 1971, coll. W. F. and J. M. Ponder (9). W. side Carnac Is., off Fremantle, W.A., 18 Dec. 1971, 2 lots, on algae, 4-8 m (sev); on low tidal algae (4), coll. W. F. and J. M. Ponder, B. R. Wilson and N. Coleman. W. end Thomson Bay, Rottnest Is., W.A., 0.2 m, on algae, 30 Jan. 1972, coll. W. F. and J. M. Ponder (sev). W. end of Salmon Bay, Rottnest Is., W.A., on *Lithothamnion*, Aug. 1969, coll. S. Slack-Smith (1). Eagle Bay, Rottnest Is., W.A., 2 lots, on *Lithothamnion* on reef edge, Aug. 1969, coll. S. Slack-Smith (4). North Pt., Rottnest Is., W.A., protected reef, on coralline algae, 3 Dec. 1969, coll. S. Slack-Smith, S.E.M. stub no. 115 (sev/15w). Pt. Peron, S. of Fremantle, W.A., 2-3 m, 27 Jan 1972, coll. W. F. and J. M. Ponder (1). Triggs, near Perth, W.A., *Caulerpa* on platform, open coast, 0-2 m, 29 Jan. 1972, coll. W. F. Ponder (sev). Horrocks Beach, N. of Geraldton, W.A., on algae on limestone platform, 9 Jan. 1972, coll. W. F. Ponder (1).

DISTRIBUTION AND HABITAT: S.W. to mid W.A. (Hopetoun to Geraldton), on algae in mid to lower intertidal and shallow sublittoral; often very abundant (fig. 11).

REMARKS: This species has a similar shell to *R. (R.) globosa* sp. nov. from the tropical Pacific and N.E. Australia but differs in radular features. It can be distinguished from the sympatric species by its globose, translucent-white shell which has a rather 'solid' appearance. The uniformly black mantle is also a useful recognition feature.

Rissoella (Rissoella) fallax sp. nov.
Figs 1b; 3b; 4f-h.

(Derivation of name: *fallax*, Latin adj. — false. Refers to superficial resemblence to *R. (Zelaxitas)* species).

Shell: Minute, thin, semi-transparent, colourless (white when dead shell), short-spired, body whorl globose, umbilicate. Spire short, about $\frac{2}{3}$ height of aperture. Protoconch of $1\frac{1}{4}$ whorls, teleoconch of up to $2\frac{2}{3}$ convex whorls. Lips of aperture rather thin, simple. Umbilicus moderate to small, simple. Smooth except for indistinct growth lines (figs 1b; 4f).

Dimensions:	Length	Diameter
Holotype	1.02 mm	0.77 mm
Paratype	0.92	0.70
Additional paratypes		
(Fairlight, N.S.W., S.E.M.)	0.98	0.72
(C.101420)	0.96	0.68
(Balmoral, N.S.W., C.101421)	1.40	0.98
(Wimbie Beach, N.S.W., C.101422)	1.70	1.15
(Pirates Bay, S. Tasm., C.101423)	1.17	0.85

Animal: Head-foot semi-transparent white, mantle black. Cephalic and oral tentacles of moderate length and width (Pirates Bay, Eaglehawk Neck, S. Tasm.) (fig. 3b).

Operculum: Typical (fig. 4g).

Radula: Central teeth slightly higher than broad, with curved cutting edge and simple base. Each tooth with about 16 very small denticle-like cusps. Lateral teeth large, triangular, each with cutting edge almost straight, inner-most cusp massive followed by 6-9 rather irregular, smaller cusps. Marginal teeth simple, plate-like (as in the subgenus *Zelaxitas*) (fig. 4h).

Opercula and radulae have been examined from Fairlight, Sydney (S.E.M. stub no. 204) and Batemans Bay, N.S.W. (S.E.M. stub no. 232).

TYPES: Holotype A.M. (C.101418).
Paratypes (1) A.M. (C.101419), 1 shell and 1 radula on S.E.M. stub no. 204.
Paratypes (2) A.M. (C.101420).
Paratype (1) A.M. (C.101421).
Paratype (1) A.M. (C.101422), 1 radula and 1 operculum on S.E.M. stub no. 232.
Paratypes (2) A.M. (C.101423).

TYPE LOCALITY: Fairlight, North Harbour, Sydney, N.S.W., on algae, low tide, 23 Dec. 1968, coll. W. F. Ponder (holotype and paratype C.101419).

LOCALITIES OF ADDITIONAL PARATYPES: Off Fairlight, North Harbour, Sydney, N.S.W., on red algae, 7-11 m, coll. J. Voorwinde (S.E.M. stub no. 204). 4-5 m off Fairlight, North Harbour, Sydney, N.S.W., coll. J. Voorwinde (C.101420). Balmoral, Sydney, N.S.W., on algae, 19 Jan. 1969, coll. W. F. Ponder and J. Voorwinde (C.101421). On exposed side of Wimbie Beach, Batemans Bay, N.S.W., on fairly exposed rocks, on large brown algae, 6 Jan. 1970, coll. W. F. Ponder and P. H. Colman (C.101422). Pirates Bay, Eaglehawk Neck, S. Tasm., under stones, low tide, 30 Mar.-2 Apr. 1970, coll. W. F. Ponder (C.101423).

ADDITIONAL MATERIAL EXAMINED: 5 m off Chinamans Beach, Middle Harbour, Sydney, N.S.W., J. Voorwinde Coll. (2). Little Coogee Bay, Sydney, N.S.W., July 1895, coll. J. Brazier (2). Gunnamatta Bay, Port Hacking, N.S.W., J. Voorwinde Coll. (1). On exposed side of Wimbie Beach, Batemans Bay, N.S.W., on algae, 6 Jan. 1970, coll. W. F. Ponder and P. H. Colman (1). Little Squally Cove, Deal Is., Bass Strait, N. Tasm., on algae, 10-30 m, 4 May 1974, coll. S. A. Shepherd (4). Murray Pass., Deal Is., Bass Strait, N. Tasm., on algae, 30-50 m, 8 May 1974, coll. S. A. Shepherd (4). East Cove, Deal Is., Bass Strait, N. Tasm., 6-15 m, 3-10 May 1974, coll. S. A. Shepherd (5). Boat Harbour, N. Tasm., on coralline algae in pools, 19 Mar. 1975, coll. W. F. Ponder and R. Kershaw (2). Pirates Bay, Eaglehawk Neck, S. Tasm., on brown algae on intertidal rocks, 30 Mar.-1 Apr. 1970, coll. W. F. Ponder (1). ?Off Low Rocky Pt., W. Tasm., 42°58.2'S, 145° 26.6'E, 84 m 10 Apr. 1973, B.M.R. stn S73-2095, M.T. 'Sprightly' (3). ?S. of West Pt., W. Tasm., 41°09.2'S, 144°24.2'E, 88 m, 14 Apr. 1973, B.M.R. stn S73-2121, M.T. 'Sprightly' (1). E.S.E. side of Gabo Is., Vic., below lighthouse, 15-18 m, on algae, Feb. 1973, coll. P. Hutchings (1). Pt. Lonsdale, Vic., on short algae, exposed edge of platform, 22 Mar. 1975, coll. W. F. Ponder and R. Burn (1).

DISTRIBUTION AND HABITAT: Mid N.S.W. to Tasm. and mid Vic., on algae in lower littoral and sublittoral; not common (fig. 11).

REMARKS: This species has proved to be rather uncommon, as usually 1 or 2 specimens only were located when it was present in samples.

The radula is diagnostic and is unusual in having similar central teeth to *Rissoella* s.s. and simple plate-like marginal teeth like those in species of *R. (Zelaxitas)* and *R. (Jeffreysiella)*. The lateral teeth are intermediate in form between species of *R. (Zelaxitas)* and *Rissoella* s.s. The shell agrees well with those of some species of *Rissoella* s.s. and *R. (Jeffreysilla)* but, although it is similar in shape to some species of *R. (Zelaxitas)*, it differs from them in texture and colour. There are no species sympatric with *R. fallax* with which it can be readily confused except *R. (Jeffreysilla) confusa robertsoni* subsp. nov. That subspecies, apart from having a very different radula, has a shell with a less inflated body whorl and a narrower umbilicus.

The 2 lots of deep-water specimens from Tasmania are only tentatively referred to this species on shell characters. They presumably had a shallow-water origin if the identification is correct.

Rissoella (Rissoella) globosa sp. nov..
Figs 1c; 3c; 5a-h

(Derivation of name: *globosa*, Latin adj. — spherical. Refers to shape of shell).

Shell: Minute, thin, semi-transparent, globose, translucent white, rather short-spired, with narrow umbilical chink. Protoconch of $1\frac{1}{4}$ whorls; teleoconch of up to $2\frac{1}{2}$ convex whorls. Inner lip of aperture slightly thickened, adapical portion not separated from parietal area by a groove. Surface smooth except for very indistinct growth lines. There is slight variation in the relative size of the umbilicus (figs 1c; 5a, c, d).

Dimensions:	Length	Diameter
Holotype	1.12 mm	0.80 mm
Paratype (Heron Is., Qld)	0.86	0.70
Figured specimens, paratypes (S.E.M.)		
(Heron Is., Qld)	0.95	0.74
(Lord Howe Is.)	0.92	0.72
(New Caledonia)	1.22	0.90

Animal: Tentacles rather short, head and snout reddish-brown, remainder of head-foot semi-translucent white. Hypobranchial pigmentation a bright yellow loop and a few dark brown or black spots. Sole with distinct median mucous slit (Heron Island) (fig. 3c).

Operculum: Typical (figs 5b, e).

Radula: Central teeth large, and with a wide cutting edge containing 8-15 rather long, sharp cusps with the median one the longest. A pair of broad, projecting basal structures present on each tooth. Lateral teeth large, with one major cusp, 3-5 cusps on either side, and, bordering these, a few denticles. All cusps rather long and sharp, somewhat variable. Each lateral tooth has a strong rib on its inner edge and the cutting edge is curved and about half the width of the base. Marginal teeth of moderate size, entire cutting edge of each tooth very finely serrated and produced into 2 very short, blunt, cusp-like structures (figs 5f-h).

Opercula and radulae have been examined from paratypes from all three type localities (S.E.M. stub nos 119, 164, 197).

TYPES: Holotype A.M. (C.101424).
Paratypes (5) A.M. (C.101425), 1 shell, 2 opercula and 2 radulae on S.E.M. stub no. 197. 2 Q.M. (MO 5718).
9/3w paratypes from Lord Howe Island, A.M. (C.101426), 1 shell, 2 opercula and 2 radulae on S.E.M. stub no. 119.
24/11w paratypes from New Caledonia, A.M. (C.101427), 1 shell, 3 opercula and 3 radulae on S.E.M. stub no. 164.

TYPE LOCALITY: Heron Island, Qld, opposite marine station buildings, on red algae on outer reef crest, 21 Sept. 1970, coll. W. F. Ponder, S.E.M. stub no. 197 (holotype and paratypes).

LOCALITIES OF ADDITIONAL PARATYPES: Nouméa, New Caledonia, on algae, on coral outcrop, near outer reef, 16 May 1971, coll. P. H. Colman, S.E.M. stub no. 164: N. side of Rabbit Is., Lord Howe Is., below low tide, in sheltered water, on brown algae on coral, 2 Feb. 1971, coll. P. H. Colman, S.E.M. stub no. 119.

ADDITIONAL MATERIAL EXAMINED: Lord Howe Is., outside reef, W. of Erscotts Passage, 18-24 m, on algae, steeply sloping rocky bottom, Feb. 1973, coll. J. Randall (2). Lord Howe Is., shore, coll. R. Bell, pres. T. Iredale (sev). Yam Is., Torres Strait, Qld, reef edge on S. side, on *Sargassum*, 6 July 1976, coll. W. F. Ponder and I. Loch (20/20w). Lizard Island, Qld, Casuarina Beach, on algae in lower littoral on coral rubble, Dec. 1975, coll. W. F. Ponder (sev). Hayman Is., Qld, J. Voorwinde Coll. (1). Lindeman Is., Qld, on algae, J. Voorwinde Coll. (1).

DISTRIBUTION AND HABITAT: New Caledonia, Lord Howe Is. and Qld, on algae, lower littoral and shallow sublittoral (fig. 11).

REMARKS: The shell of this species differs from that of *R. (R.) atrimacula* sp. nov. from Western Australia only in its generally slightly smaller size. The radular characters, however,

readily distinguish the two species. In particular can be noted the longer cuspate cutting edge of the lateral teeth of *R. (R.) atrimacula* relative to the length of the base, the totally different marginal teeth of the two species and the relatively much longer main cusp on the lateral and central teeth in *R. (R.) globosa*. Although the shells of these two species are virtually indistinguishable, their geographical separation should prevent difficulties in their identification.

Rissoella (Rissoella) vitrea sp. nov.
Figs 1d-f; 3d; 6a-f

(Derivation of name: *vitrea*, Latin adj. — glassy, transparent. Refers to appearance of shell).

Shell: Minute, thin, colourless, transparent, narrowly to moderately umbilicate, typically colourless but often semi-transparent to semi-opaque white, with narrow, colourless axial streaks. Spire of moderate height to rather low. Protoconch of about 1¼-1½ whorls, teleoconch of up to 2½ convex whorls. Inner lip of aperture rather thin, adapical portion attached to parietal area. Umbilicus variable, sometimes almost closed, in other specimens moderate to rather wide. Surface smooth, with very indistinct growth lines (figs 1d-f; 6a-c).

Dimensions:	Length	Diameter
Holotype	0.95 mm	0.65 mm
Paratype	0.97	0.65
Figured specimens		
(Aldinga, S.A.)	1.30	0.94
(Thevenard, S.A.)	0.86	0.62
S.E.M. (Paratype)	0.93	0.62
(Rottnest Is., W.A.)	1.40	0.95
(Thevenard, S.A.)	0.88	0.62

Animal: Head-foot black, tips of tentacles white, sole greyish. Visceral mass and mantle black. Cephalic and oral tentacles rather short, oral tentacles broad (Aldinga, S.A.) (fig. 3d.).

Operculum: Typical (fig. 6d).

Radula: Central teeth large, with strongly convex cutting edge having 10-13 irregular, sharp cusps. A pair of basal projections present on each tooth. Each lateral tooth with a strong, rather long ridge on its inner side and a relatively short, strongly convex cutting edge, which has one prominent median cusp and 13-18 smaller cusps. The base is about twice the width of the cutting edge. Marginal teeth rather large, with 11-14 sharp cusps, the apical one stronger and larger than the others (figs 6e, f).

Radulae and opercula have been examined from the paratype series (S.E.M. stub no. 112), near Albany (S.E.M. stub no. 255, 257), North Point, Rottnest Island (S.E.M. stub no. 114), Port Denison, N. of Geraldton (S.E.M. stub no. 250) all from W.A. and Thevenard, near Ceduna (S.E.M. stub no. 244) and Snapper Point, Aldinga (S.E.M. stub no. 231) from S.A.

TYPES: Holotype A.M. (C.101428)
Paratypes (1 20/20w) A.M. (C.101429) 4 W.A.M. (WAM1377-75), 1 shell, 2 opercula and 2 radulae on S.E.M. stub no. 112

TYPE LOCALITY: Denham, Shark Bay, W.A., on short algae on flats, in front of township, about 1 m below low tide, 10 Jan. 1972, coll. W. F. and J. M. Ponder.

ADDITIONAL MATERIAL EXAMINED: Exposed reef just N. of Snapper Pt., Aldinga, S.A., low tide, 4 lots, on short brown algae, S.E.M. stub no. 231 (3); on brown algae (3); on coralline algae (1); stone washings, S.E.M. stub no. 231 (2), 11 Jan. 1970, coll. W. F. Ponder.

Waldegrave Is., W. side Eyre Peninsula, S.A., on algae, 1 m, 25 Oct. 1973, coll. S. A. Shepherd (2). W. side of Thevenard, near Ceduna, S.A., semi-sheltered rock platform on short algae, 6 Dec. 1971, coll. W. F. and J. M. Ponder, S.E.M. stub no. 244 (1). South Pt., S. of Two Peoples Bay, near Albany, S.W.A., on large brown algae on exposed shore, 3 Feb. 1972., coll. W. F. Ponder, S.E.M. stub nos 255, 257 (5). W. end reef, Rottnest Is., W.A., on *Lithothamnion* from intertidal reef edge, Aug. 1969, coll. S. Slack-Smith (1). North Pt., Rottnest Is., W.A., protected reef, on coralline algae, 3 Dec. 1969, coll. S. Slack-Smith, S.E.M. stub no. 114 (8). Port Denison, 65 km S. of Geraldton, W.A., on algae on limestone reef, 0-2 m, 24 Jan. 1972, coll. W. F. and J. M. Ponder, S.E.M. stub no. 250 (sev). Red Bluff, N. of Monkey Mia, E. side of Peron Peninsula, Shark Bay, W.A., on brown algae, on sandflats, 11 Jan. 1972, coll. W. F. and J. M. Ponder (1). Pt. Quobba, W.A., on algae, exposed limestone reef platform, between tides, 12 Jan. 1972, coll. W. F. and J. M. Ponder (7). Just S. of wreck of S.S. 'Mildura', N.W. Cape, W.A., on limestone reef platform, 0-2 m, moderately exposed, 18 Jan. 1972, coll. W. F. and J. M. Ponder (2).

DOUBTFUL IDENTIFICATIONS: Glenelg, Gulf St. Vincent, S.A., J. Voorwinde Coll. (1). 80 km S.E. of Kangaroo Is., S.A., 37°00'S, 138°33'E, 77 m, 26 June 1962, H.M.A.S. 'Gascoyne' G2/76/62 (1). Tumby Bay, S.A., coll. Mrs. J. Thompson, J. Voorwinde Coll., 3 lots (sev).

DISTRIBUTION AND HABITAT: Mid S.A. to N.W.A. (N.W. Cape), in lower littoral and shallow sublittoral; sometimes abundant (fig. 11).

REMARKS: The shell can be separated from the other Western Australian species, *R. (R.) atrimacula*, by its narrower spire and smaller size. The radula shows considerable differences from *R. (R.) atrimacula* and is the closest of the Australian species to the type species of *Rissoella*, *R. albella* (Alder), from Europe. In shell features *R. (R.) vitrea* is very similar to narrow specimens of *R. (J.) confusa umbilicata* subsp. nov. from south Western Australia and *R. (J.) confusa confusa* subsp. nov. from Queensland. Both of these subspecies, however, have a totally different radula.

The radulae of the two South Australian lots examined are very similar to those of the Western Australian specimens, the only apparent difference being that the central teeth are a little narrower in the 2 specimens examined from Aldinga. In the mount of the radula from Ceduna the lateral teeth obscured the central teeth so that their shape could not be ascertained. The marginal and lateral teeth however are typical. The type series, most of the specimens from Rottnest Island and occasional shells from South Australia are colourless and glassy. The remainder are similar to *Rissoella (Jeffreysilla) zebra* (Thiele) from East Africa in having opaque or semi opaque white shells with axial colourless streaks.

Subgenus **Jeffreysilla** Thiele, 1925
Type species (monotypy): *Rissoella zebra* Thiele, 1925.

Synonym *Phycodrosus* Rehder, 1943.
Type species (original designation): *Rissoella caribaea* Rehder, 1943 (fide Robertson, 1961).

DIAGNOSIS: *Shell:* Depressed, globose, with small to large umbilicus. *Head:* With short, rather narrow tentacles. *Radula:* With rather wide central teeth, the entire cutting edge taken up by a pair of broad cusps separated by a median notch. Lateral teeth elongate, with 1 or 2 cusps. Marginal teeth simple, triangular. *Jaw:* Rodlets smooth, not dentate or comb-like as in the other groups (fide Thiele, 1925; not confirmed).

REMARKS: The species so far described in this subgenus are largely tropical or subtropical in distribution. The subgenus has not previously been recognised from Australasia, the only species definitely attributed to it being the type species and *R. caribaea*, the former from Tanganyika (= Tanzania) and the latter from Florida, Bahama Islands and western Puerto Rico (Robertson, 1961).

The radulae of species in this subgenus do not tend to be particularly useful at the species level because they lack prominent cusps and, as far as the Australian forms are concerned, the teeth are very similar in shape. Thus, because the shell features are very similar and because the external appearance of the living animal has not been observed in most cases, the Australian forms are here regarded as geographic subspecies.

Rissoella (Jeffreysilla) confusa sp. nov.

(Derivation of name: *confusus,* Latin adj. — confused. Refers to the difficulty in classifying this species).

Shell: Minute, thin, semi-opaque to transparent, colourless to white, with very narrow to broad umbilicus. Spire slightly less to slightly greater than height of aperture. Protoconch of 1¼-1½ whorls, teleoconch of 2½ convex whorls. Inner lip of aperture slightly to moderately thickened. Surface smooth but not highly glossy; with indistinct growth lines.

Operculum: Typical.

Radula: Typical of subgenus and virtually identical in the 3 subspecies here recognised. Central teeth more or less rectangular, with lateral teeth narrowly triangular and marginal teeth broadly triangular. All teeth are finely serrated.

REMARKS: Other details are given below under the typical subspecies.

This species, as here recognised, has a number of apparently distinct geographic forms which are given subspecific names. The amount of material available is regrettably small and it is possible that the examination of more comprehensive collections will necessitate changes in the status of the taxa here recognised.

Rissoella (Jeffreysilla) confusa confusa subsp. nov.
Figs 1g; 3e; 7a-e

Shell: Transparent, colourless, surface glossy. Umbilical chink typically narrow, absent in juveniles. Protoconch of 1¼ whorls, teleoconch up to 2½ convex whorls. Spire about equal to height of aperture in length. Inner lip very slightly concave, almost straight (figs 1g; 7a, c, d).

Dimensions:	Length	Diameter
Holotype	1.50 mm	0.96 mm
Paratypes	1.40	0.92
	1.37	0.90
Figured specimens (S.E.M.)		
(Paratype)	1.00	0.68
(New Caledonia)	1.16	0.75
(New Hebrides)	1.02	0.69

Animal: Head dark grey; tentacles dark grey dorsally, unpigmented ventrally and laterally, of intermediate length, rather narrow. Foot black dorsally, sole dirty white. Mantle pigmentation visible through shell and includes a large, irregular (often figure 8-shaped), pale yellow area and one large and several small black spots. Remainder colourless except for visceral area which is black or dark brown (Lizard Island) (fig. 3e).

Operculum: Fig. 7b.

Radula: Fig. 7e.

Radulae and opercula examined from Lizard Island (S.E.M. stub nos 158, 166) and New Caledonia (no. 163).

TYPES: Holotype A.M. (C.101430)
Paratypes (11/1w) A.M. (C.101431), 1 shell, 2 radulae and 2 opercula on S.E.M. stub nos 158, 166. 3 Q.M. (MO5719).

TYPE LOCALITY: Lizard Island, Qld, lagoonal reef flats between Lizard and Palfrey Island, 1.5 m, on coralline algae growing on sandy bottom with isolated coral outcrops, 11 Dec. 1974, coll. W. F. Ponder, P. H. Colman and I. Loch.

ADDITIONAL MATERIAL EXAMINED: N. entrance of Aoki Harbour, Malaita Is., Solomon Ids, coral rubble and sand bottom, 18 Aug. 1973, coll. P. H. Colman (10). Off Hotel Tanna, Tanna Is., New Hebrides, on algae on exposed reefs, 1 Feb. 1967, coll. W. F. Ponder, S.E.M. stub no. 120 (4). Pt. Adel, Port Vila, Efaté, New Hebrides, beneath coral blocks, low tide, Jan. 1967, coll. W. F. Ponder (1). Out of Nouméa, New Caledonia, on algae on coral outcrop, near outer reef, 16 May 1971, coll. P. H. Colman, S.E.M. stub no. 163 (5/1w). Murray Is., Torres Strait, Qld, 9-15 m, coll. C. Hedley (8). Lizard Is., Qld, reef off S. end of Casuarina Beach, 1-2 m, 3 Dec. 1974, coll. P. H. Colman and I. Loch (sev). Lizard Is., Qld, reef flats off exposed point N. of Crystal Beach, 2 m, 11 Dec. 1974, coll. P. H. Colman (4). Macgillivray Reef, Lizard Is., Qld, on *Halimeda*, 5 m, 10 Dec. 1974, coll. W. F. Ponder and P. H. Colman (9). Opal Reef, N.E. of Port Douglas, Qld, on algae on sandy rubble at base of niggerhead, 29 m, 26 Nov. 1972, coll. P. H. Colman (2). Euston Reef, E.N.E. of Cairns, Qld, 21 m, at bottom of sandy slope below steep coral walls, S.W. side of reef, 30 Nov. 1972, coll. P. H. Colman, (2 lots) (3). Hayman Is., Qld, J. Voorwinde Coll. (1). Heron Is., Qld, 3 lots, 11 m (1); 37 m (1); 4 m, S.E. side (1), J. Voorwinde Coll.

DISTRIBUTION AND HABITAT: Solomon Ids, New Hebrides, New Caledonia and N. to mid Qld, on algae in lower littoral and shallow sublittoral (fig. 12).

REMARKS: Differs from the subspecies described below in its usually small umbilical chink, colourless glassy shell and nearly straight inner lip. The only other known tropical Indo-Pacific species is *R. (Jeffreysilla) zebra* Thiele, 1925 which is relatively broader and has translucent axial streaks alternating with broader opaque white areas.

Rissoella (Jeffreysilla) confusa robertsoni subsp. nov.
Fig. 1h

Shell: Minute, semi-translucent to semi-opaque, white, thin, umbilicate, spire of moderate length, body whorl not much expanded. Protoconch of 1½ whorls, rather flattened, teleoconch of 2½ convex whorls. Aperture simple, lips thin, inner lip separated from much of parietal area by umbilicus. Umbilicus moderate (fig. 1h).

Dimensions:	Length	Diameter
Holotype	1.00 mm	0.67 mm
Additional paratypes	1.12	0.77
	0.80	0.62

Animal: Not observed alive.

Operculum: Typical.

Radula: Typical, identical to that of other subspecies. Radula and operculum obtained from specimen collected with holotype.

TYPES: Holotype A.M. (C.101452)
Paratype, 1 operculum and 1 radula on S.E.M. stub no. 205 (shell from which radula and operculum obtained broken). Paratypes (2) A.M. (C.101453).

TYPE LOCALITY: Inside breakwater, S. side of Ulladulla, N.S.W., on sheltered reef on small brown algae, 5 Jan. 1970, coll. W. F. Ponder and P. H. Colman (holotype) (S.E.M. stub no. 205).

LOCALITY FOR ADDITIONAL PARATYPES: Green Cape, on Disaster Bay side, N.S.W., between rocks, 15 m, 13 Feb. 1973, coll. P. Hutchings.

ADDITIONAL MATERIAL EXAMINED: Collaroy Beach, Sydney, N.S.W., in shell sand, 1950-1960, J. Voorwinde Coll. (1). Fairlight, Sydney, N.S.W., on algae at low tide, 23 Dec. 1968, coll. W. F. Ponder (1). Boat Harbour, N. Tasm., on brown algae, 19 Mar. 1975, coll. W. F. Ponder and R. Kershaw (1).

DISTRIBUTION AND HABITAT: Mid N.S.W. to N. Tasm., on algae in lower littoral and shallow sublittoral; uncommon (fig. 12).

REMARKS: Very similar to *R. (J.) confusa umbilicata* subsp. nov. but that subspecies usually has a slightly broader spire and has a less flattened protoconch. The small differences in the shell are considered to be of subspecific value mainly because of the wide geographic separation of the two forms. This subspecies is also very similar to *R. (J.) confusa confusa* but it differs from this tropical form in the semi-translucent to semi-opaque shell, more convex spire outline and flattened protoconch.

This subspecies is named for Dr Robert Robertson of the Academy of Natural Sciences of Philadelphia who made an exhaustive study of the nomenclatural problems of the Rissoellidae.

Rissoella (Jeffreysilla) confusa umbilicata subsp. nov.
Figs 1i, j; 7f-k

(Derivation of name: *umbilicatus,* Latin, shaped like a navel. Refers to the prominent umbilicus of the shell).

Shell: Distinguished from the other subspecies by its broadly ovate shape and prominent, broad umbilicus. Umbilicus distinct but relatively narrow in juveniles. Spire about equal to or slightly greater than height of aperture. Protoconch of 1¼ whorls, teleoconch of up to 2¾ convex whorls. The large umbilicus results in the adapical section of the inner lip being detached or semi-detached from the parietal wall in adult specimens except for that portion in the adapical corner of the aperture. Surface shining but not highly glossy, semi-translucent to semi-opaque, colourless to white (fig. 1i,j; 7f, i).

Dimensions:	Length	Diameter
Holotype	1.22 mm	0.78 mm
Paratypes	1.48	0.86
	1.20	0.82
	1.42	0.90
Figured specimens (S.E.M.)		
(Paratype)	1.31	0.87
(Hopetoun Jetty, S.W.A.)	1.04	0.73
(Off Dunsborough, S.W.A.)	1.08	0.74

Animal: Not observed alive.

Operculum: Figs 7g, j.

Radula: Typical of species (figs 7h, k).

Opercula and radulae examined from Hopetoun, S.W.A. (S.E.M. stub no. 199, 242), off Dunsborough, S.W.A. (S.E.M. stub no. 122), Thevenard, S.A. (S.E.M. stub no. 243) and the type series.

TYPES: Holotype A.M. (C.101454).
Paratypes (4) A.M. (C.101455), 1 shell, 2 radulae and 2 opercula on S.E.M. stub no. 147. 2 W.A.M. (WAM 407-76).

TYPE LOCALITY: Mississippi Bay, 48 km E. of Esperance, S.W.A., on sheltered side of west head of bay, 0-2 m, on algae, 6 Feb. 1972, coll. W. F. Ponder.

ADDITIONAL MATERIAL EXAMINED: Largs Bay, S.A., J. C. Verco Coll. (S.A.M.) (2). W. side of Thevenard, near Ceduna, S.A., semi-sheltered rock platform on short algae, 6 Dec. 1971, coll. W. F. and J. M. Ponder, S.E.M. stub no. 243 (sev). Pt. Sinclair, S.A., 1 m, on algae, 9 Feb. 1972, coll. W. F. and J. M. Ponder (10). E. of Observatory Is., Recherche Archipelago, S.W.A., Jan. 1944, coll. G. P. Whitley (1). E. side of Hopetoun Jetty, S.W.A., on algae, W. side of sheltered limestone reef, 0-1 m, 4 Feb. 1972, coll. W. F. and J. M. Ponder, S.E.M. stub no. 242 (25). Hopetoun Jetty, S.W.A., on algae, semi-exposed and semi-sheltered reef, 0.5-2 m, 5 Feb. 1972, coll. W. F. Ponder, S.E.M. stub no. 199 (2/w). Off Dunsborough, W.A., on algae, on limestone and coral reef, 16 m, 27 Dec. 1971, coll. W. F. Ponder, B. R. Wilson and N. Coleman, S.E.M. stub no. 122 (5).

DISTRIBUTION AND HABITAT: W.S.A. and S.W.A., on algae in lower littoral and shallow sublittoral (fig. 12).

REMARKS: This subspecies differs from the tropical Pacific subspecies *R. (Jeffreysilla) confusa confusa* in its slightly larger, more opaque, less glossy shell, and larger umbilical chink and in the distinctly concave inner lip of the aperture, this lip in the typical subspecies being almost straight. A small series from 16 m off Dunsborough, W.A. has a slightly narrower spire and slightly smaller umbilicus than the other populations examined. In shape the shells in this population resemble specimens of *R. (J.) confusa robertsoni* but specimens of that subspecies have a more flattened protoconch.

Subgenus **Zelaxitas** Finlay, 1927.

Type species (original designation): *Laevilitorina cystophora* Finlay, 1924.

DIAGNOSIS: *Shell:* Minute, with short spire, inflated body whorl, non-umbilicate or umbilicate, brown. *Head:* Tentacles short, broad. *Radula:* With small, broad central teeth, having 2 small cusps and a long pair of oblique basal processes. Lateral teeth with numerous (about 11) rather long cusps on a long, straight cutting edge. Inner edge of lateral teeth with a strong, oblique ridge running to basal margin. Marginal teeth long, plate-like with a pair of very weak, indistinct, rounded, cusp-like structures near inner end.

REMARKS: Ponder (1966) transferred *Zelaxitas* from the Littorinidae, where it was originally placed, to the Rissoellidae and discussed the 2 New Zealand species. This subgenus has not previously been recognised outside New Zealand.

Species included in this subgenus are very similar to *Rissoella (Rissoella)* in most radular features except that the central teeth are relatively small and have reduced cusps. The

consistently massive, simple marginal teeth are similar to those found in *R. (R.) fallax* but are unlike those of any other species of *Rissoella (Rissoella).* They are also like the outer marginal teeth of species of *R. (Jeffreysiella).* The species included in *R. (Zelaxitas)* can be regarded as a compact Australasian group characterized by their short-spired, globose brown shells and rather distinctive radula.

Rissoella (Zelaxitas) imperforata sp. nov.
Figs 1k; 3f; 8a, b

(Derivation of name: *im* (= in), Latin-without; *perforare,* Latin verb — to make a hole. Refers to lack of umbilicus in shell).

Shell: Minute, thin, smooth and shining, translucent brown to semi-opaque brown, top of spire often eroded to white. Spire about half as high as aperture. Protoconch of 1½ whorls, colourless, teleoconch of up to 2 strongly convex whorls. Aperture large with inner lip slightly thickened, greyish-white to yellowish-white. A very narrow umbilical chink with a sharp external edge present in juveniles, adults non-umbilicate. Surface with indistinct growth lines only (figs 1k; 8a).

Dimensions:	Length	Diameter
Holotype	1.00 mm	0.75 mm
Paratypes	0.92	0.70
	0.96	0.74
Figured specimen (paratype)	0.94	0.74

Animal: With short, broad tentacles; foot, tentacles and head grey dorsally (due to black pigment finely scattered over surface), colourless ventrally. Mucous slit in posterior half of sole. Mantle uniformly black (Eaglehawk Neck) (fig. 3f).

Operculum: Typical.

Radula: Very like that of *R. (Z.) micra* (Finlay) but with the central teeth more expanded laterally and with a weaker pair of cusps on the central teeth which show a slight tendency towards serration on their outer edges (fig. 8b).

Radulae and opercula examined from Eaglehawk Neck, S. Tasm. (S.E.M. stub nos 116, 222).

TYPES: Holotype A.M. (C.101457).
Paratypes (44/3 w) A.M. (C.101458) 1 shell, 2 radulae and 2 opercula on S.E.M. stub no. 116, 4 T.M. (E9239), 2 N.M.V. (F.30003).

TYPE LOCALITY: Pirates Bay, Eaglehawk Neck, S. Tasm., on brown algae, lower littoral, 30-31 Mar. 1970, coll. W. F. Ponder.

ADDITIONAL MATERIAL EXAMINED: East Cove, Deal Is., Bass Strait, N. Tasm., 147°20'E, 39°30'S, 6-15 m, 3-10 May 1974, coll. S. A. Shepherd (4). Boat Harbour, N. Tasm., on coralline algae in pools, 19 Mar. 1975, coll. W. F. Ponder and R. Kershaw (8). N. end of Pirates Bay, Eaglehawk Neck, S. Tasm., on large brown algae, low tide, 2 Apr. 1970, coll. W. F. Ponder, S.E.M. stub no. 222 (sev). Pirates Bay, Eaglehawk Neck, S. Tasm., intertidal, on coralline algae (1); under stones (5), 30-31 Mar. 1970, coll. W. F. Ponder. Eaglehawk Neck, S. Tasm., pres. C. Hedley (1). Primrose Pt., E. side of Frederick Henry Bay, S. Tasm., on matted green algae, low tide, 31 Mar. 1970, coll. W. F. Ponder (1). Roches Beach, W. side of Frederick Henry Bay, S. Tasm., on coralline algae, semi-sheltered reef, 1 Apr. 1970, coll. W. F. Ponder and E. Turner (2). Pt. Lonsdale, Vic., on coralline algae in pools, 18 Sept. 1973, coll. W. F. Ponder and R.

Burn (4). Port Fairy, Vic., 4 km W. of town, 19 Aug. 1973, coll. W. F. Ponder and R. Burn, 2 lots, on brown algae (6); coralline algae (5).

DISTRIBUTION AND HABITAT: Tasm. and mid-Vic., on algae in lower littoral; rarely common (fig. 13).

REMARKS: This species is extremely close to *R. (Z.) micra* (Finlay) in size and general appearance but the small differences in the central teeth of the radula and in the adult shell between the 2 species serve to separate them. The adult shell of *imperforata* is non-umbilicate but in *micra* it is distinctly umbilicate. In addition, the spire in *micra* tends to be relatively higher. The radula of *R. (Z.) imperforata* differs from that of *R. (Z.) micra* in having relatively broader central teeth which have weaker cusps.

This species has some similarity with *R. (Z.) cystophora* (Finlay) from New Zealand but that species has an even larger aperture, thinner inner lip and relatively shorter spire (fig. 8j).

Rissoella (Zelaxitas) micra (Finlay, 1924).
Figs 1l-n; 3g; 8c-i

Laevilitorina micra Finlay, 1924:522, fig. 5
Zelaxitas micra.— Finlay, 1927: 375.
Notosetia fulva Laseron, 1950: 279, fig. 69.
Rissoella (Zelaxitas) micra.— Ponder, 1966: 170, pl. 2, figs 1-5

Shell: Minute, thin, translucent, brown, somewhat shining. Spire greater than half height of aperture to almost equal in height. Protoconch of 1½ colourless whorls, teleoconch up to about 2¼ strongly convex whorls. Aperture large, inner lip slightly thickened, white. Umbilicus prominent in adults, externally bordered by a sharp edge. Umbilical chink small in juveniles. Surface with indistinct growth lines only (figs 1l-n; 8c, d, f).

Dimensions:	Length	Diameter
Holotype	0.72 mm	0.60 mm (from Ponder, 1966, but dimensions reversed in error)
Figured specimens		
(lectotype of *Notosetia fulva*)	1.20	0.88
(Fairlight, Sydney)	0.95	0.70
(Whangarei Heads, N.Z.)	0.80	0.60
S.E.M. (Fairlight, Sydney)	1.10	0.76
	0.86	0.68
(Wellington, N.Z.)	1.10	0.84

Animal: Tentacles short, rather broad, colourless to grey, some greyish-brown pigmentation dorsally on head and sides of foot. Sole white with mucous slit in posterior half. Anterior edge of foot indented. Two dark-brown pigment spots in mantle on either side of body whorl show through shell (Middle Harbour, Sydney) (fig. 3g).

Operculum: Typical (fig. 8e).

Radula: Central teeth small, each with cutting edge having 2 short but rather strong cusps; basal area bulges laterally into 2 short, rounded expansions and a pair of wing-like basal projections emerge obliquely from the middle of the base. Lateral teeth with 9-11 (usually 11) long, sharp cusps on a straight cutting edge. Inner side of each lateral tooth with a long ridge-like structure. Marginal teeth simple plates showing 2 weak cusp-like folds on their inner ends (figs 8g-i).

Radulae and opercula examined from Fairlight and Long Reef, Sydney, N.S.W. (S.E.M. stub nos 113, 200, 201), Primrose Point, S. Tasmania (S.E.M. stub no. 221), and Island Bay, Wellington, New Zealand (S.E.M. stub no. 210).

TYPES: *L. micra,* Auckland Institute and Museum, Auckland (holotype and paratypes). *Notosetia fulva,* A.M., lectotype (C.101459), here designated, and 10 paralectotypes (C.101460).

TYPE LOCALITIES: *Laevilitorina micra,* Taieri Beach, Otago, New Zealand, on algae.

Notosetia fulva, Long Reef, Collaroy, N.S.W., under stones.

ADDITIONAL AUSTRALIAN MATERIAL EXAMINED: Forster, N.S.W., on fine brown algae, on boulder bank, low tide, 4 Jan. 1969, coll. W. F. Ponder (2/6 w). Fingal Bay, Port Stephens, N.S.W., on beach in shell sand, 1950-1960, J. Voorwinde Coll., 2 lots (3). N. side Long Reef, Collaroy, N.S.W., on *Corallina,* low tide, 4 Sept. 1975, coll. A.M. party (4); under stones, 21 Jan. 1975, coll. W. F. Ponder (10). Long Reef, Collaroy, N.S.W., on algae, 1950-1960, J. Voorwinde Coll., 3 lots (8). On outer point, Long Reef, Collaroy, N.S.W., on short brown algae, 10 Mar. 1970, coll. P. H. Colman, S.E.M. stub no. 201 (1). Chinamans Beach, Sydney, N.S.W., 3-7 m, J. Voorwinde Coll. (1). Fairlight, Sydney, N.S.W., low tide, 3 lots, on short algae, S.E.M. stub no. 113; on coralline algae, S.E.M. stub no. 200 (25); under stones (4w), 23 Dec. 1968, coll. W. F. Ponder. Near Fairlight Pool, Manly, Sydney, N.S.W., on coralline algae, 16 July 1975, coll. A.M. party (7). Off Sow and Pigs Reef, Sydney, N.S.W., 9 Jan. 1879, coll. J. Brazier (1). Balmoral, Sydney, N.S.W., on brown algae, 18 Jan. 1969, coll. W. F. Ponder and J. Voorwinde (9w). Shell Harbour, N.S.W., on algae, J. Voorwinde Coll. (1). S. side of Ulladulla, N.S.W., on sheltered reef, inside breakwater, on small brown algae, 5 Jan. 1970, coll. W. F. Ponder and P. H. Colman (sev). S. side of Ulladulla, N.S.W., on moderately exposed rock platform, outside breakwater, on small brown algae, 5 Jan. 1970, coll. W. F. Ponder and P. H. Colman (1). Ulladulla, N.S.W., in shell sand, 1950-1960, J. Voorwinde Coll. (1). Wimbie Beach, Batemans Bay, N.S.W., on fairly exposed rocks, 2 lots, on large brown algae (sev); coralline algae (8), 5 Jan. 1970, coll. W. F. Ponder and P. H. Colman. Bittangabee, N. side of Green Cape, N.S.W., on algae, low tide, 13 Feb. 1973, coll. W. F. Ponder (9). S. end of Green Cape, N.S.W., on algae, 16 m, 13 Feb. 1973, coll. S. A. Shepherd (5). Pirates Bay, Eaglehawk Neck, S. Tasm., under stones, 30 Mar. — 2 Apr. 1970, coll. W. F. Ponder (1). Primrose Pt., E. side of Frederick Henry Bay, S. Tasm., low tide, 2 lots, on coralline algae in pools, S.E.M. stub no. 221 (3); on matted algae (1/2w), 30 Mar. 1970, coll. W. F. Ponder. E.S.E. side of Gabo Is., Vic., 28 m, on algae and detritus below lighthouse, Feb. 1973, coll. P. Hutchings (6/2w).

DISTRIBUTION AND HABITAT: New Zealand, N.S.W., E. Tasm. and far E. Vic., on algae and beneath stones in mid to lower littoral and on algae in shallow sublittoral, often abundant (fig. 13).

REMARKS: The Australian material of this species is indistinguishable from the 2 lots of New Zealand specimens available for comparison in radular and shell characters. The Australian specimens often tend to develop a slightly wider umbilicus than the available New Zealand material but some of the Australian shells fall within the range of variation of the New Zealand examples.

Subgenus **Jeffreysiella** Thiele, 1912 (August).
Type species (original designation): *J. notabilis* Thiele, 1912.
Synonym *Heterorissoa* Iredale, 1912 (October).
Type species (original designation): *H. secunda* Iredale, 1912.

DIAGNOSIS: *Shell:* With spire elevated to moderately elevated, non-umbilicate to narrowly umbilicate, often large for genus. Protoconch usually deviated. *Radula:* With large, multicuspate central teeth which are sometimes asymmetrical. Lateral teeth large, with numerous minor cusps and one large terminal cusp. Two pairs of marginal teeth; inner pair rather simple or similar to (but smaller than) the lateral teeth; outer marginal teeth simple plates. *Head:* With long, slender tentacles.

REMARKS: Thiele (1925) suggested that *Heterorissoa* was a synonym of *Jeffreysiella* but the only evidence given was that Iredale included *Jeffreysia edwardiensis* Watson, 1880 in *Heterorissoa* which Thiele regarded as belonging to *Jeffreysiella*. Iredale (1912) separated his new genus from *Rissoella* on the basis that the operculum lacked an internal peg, but the examination of a topotype (fig. 10b) shows it has an operculum typical of the genus *Rissoella*. Unfortunately the radula could not be obtained from the remains of 2 dried animals available but the shell characters are identical to those of *Jeffreysiella* species from New Zealand and Australia so that *Heterorissoa* can be considered to be a subjective synonym of *Jeffreysiella*.

This subgenus is distinctive in the generally tall-spired shell bearing a more-or-less deviated protoconch, and in having 7 teeth instead of the usual 5 in each row of the radula.

Rissoella (Jeffreysiella) colleenae sp. nov.

Shell: Rather loosely coiled, transparent to semi-translucent, colourless to whitish, spire rather elongate. Protoconch of $1\frac{1}{4}$ convex whorls, teleoconch of $2\frac{1}{4}$-$2\frac{3}{4}$ convex whorls. Inner lip thin. Umbilical chink very narrow or absent, no umbilicus present.

Operculum: Typical.

Radula: Central teeth highly asymmetrical, cusps on right side strongly developed, those on left side reduced to minute denticles and displaced to left dorso-lateral margin. Basal processes long, narrow, basal margin strongly convex. Lateral teeth triangular, very elongate, terminating in a sharp cusp, the inner margin only denticulate. Inner marginal teeth simple curved plates, the outer marginals simple sub-rudimentary plates.

REMARKS: This species is much smaller than all others in the subgenus. Two geographic subspecies can be recognised.

Rissoella (Jeffreysiella) colleenae colleenae subsp. nov.
Figs 2a; 9a-c

Shell: Minute, thin, transparent, colourless, non-umbilicate with tall spire, slightly longer than height of aperture. Teleoconch of up to about 2¼ convex whorls. Adapical portion of inner lip attached to parietal area. Umbilical chink narrow, small (figs 2a; 9a).

Dimensions:	Length	Diameter
Holotype	0.93 mm	0.54 mm
Paratypes	0.94	0.57
	0.87	0.50
Figured specimen (S.E.M.) (Paratype)	0.93	0.52

Animal: Not observed alive.

Operculum: Typical (fig. 9b).

Radula: Central teeth broad with 6-8 large, sharp cusps, increasing in size from left to right to the 5th cusp (or in some cases the 6th)the following cusp(s) smaller. A small group of about 8 denticles on right side near upper margin of each tooth probably represents right-hand cusps, the large 5th cusp probably representing original median cusp. A swelling on right side of each central tooth merges with the right basal process, the left basal process being simple. Lateral teeth triangular each with a very long, sharp, smooth median cusp and about 10 denticles along the inner margin below the base of the cusp. Marginal teeth simple, curved plates, the cutting edges bluntly rounded. Outer marginals much reduced, simple plate-like structures (fig. 9c).

Operculum and radula examined from type locality.

TYPES: Holotype A.M. (C. 100000).
Paratypes (8) A.M.(C.100001), 1 shell, 2 radulae and 2 opercula on S.E.M. stub no. 203.
2 W.A.M. (WAM1378-75).

TYPE LOCALITY: Twilight Cove, 6 km W. of Esperance, S.W.A. on west headland, on algae on exposed rocky shore, 26 Jan. 1972, coll. W. F. and J. M. Ponder.

ADDITIONAL MATERIAL EXAMINED: Mississippi Bay, 48 km E. of Esperance, S.W.A., on algae, 0-2 m, 6 Feb. 1972, coll. W. F. Ponder (2). Bunker Bay, 11 km W. of Dunsborough, S.W.A., on algae, 24 Dec. 1971, coll. W. F. and J. M. Ponder (2).

DISTRIBUTION AND HABITAT: S.W.A., on algae in lower littoral (fig. 14).

REMARKS: This subspecies differs from *R. (J.) colleenae pacifica* subsp. nov. in its slightly smaller, less elongate, transparent shell and in minor details of the radula.

The new species is named for Miss Colleen Robinson as a small mark of gratitude for her very considerable help over several years.

Rissoella (Jeffreysiella) colleenae pacifica subsp. nov.
Figs 2b; 3h; 9d-f

(Derivation of name: Pacific Ocean).

Shell: Minute, thin, fragile, semi-transparent, white, non-umbilicate, with elongate spire (longer than height of aperture). Protoconch colourless, transparent, teleoconch up to 2¾ convex whorls. Inner lip of aperture typically attached to parietal area over most of its adapical half but sometimes partly separated by a very narrow fissure. Umbilical area usually represented by a minute chink (figs 2b; 9d).

Dimensions:	Length	Diameter
Holotype	1.10 mm	0.55 mm
Paratypes	1.06	0.57
	1.08	0.58
	1.10	0.57
Figured specimen (S.E.M.) (Paratype)	1.24	0.64

Animal: Head — foot translucent white, with long oral and cephalic tentacles. Pigmented parts of hypobranchial gland pale brown with a dark brown spot centrally placed on last part of body whorl (N. Stradbroke Is., Qld) (fig. 3h).

Operculum: Typical (fig. 9e).

Radula: Central teeth large, each with 6-7 sharp cusps, gradually increasing in size from left to right to the second to last cusp, the right-hand cusp being slightly smaller than the one preceding it. The original left-hand cusps are reduced to denticles and their position is distorted so that they lie near the dorso-lateral (left) margin. This margin is turned forwards and merges with the left basal process. The basal processes are rather elongate and narrow. The lateral teeth are elongately triangular and are bluntly serrated on their inner margins. Each has a sharp and short single cusp but the entire tooth has a long cusp-like appearance. Marginal teeth simple, inner marginals simple, curved plates; outer marginals simple plates (fig. 9f).

Operculum and radula observed from type locality.

TYPES: Holotype A.M. (C.101461).
Paratypes (16/17 w) A.M. (C.101462), 1 shell, 2 radulae and 3 opercula on S.E.M. stub no. 191. 3 Q.M. (MO 5720).

TYPE LOCALITY: N.W. side of Pt. Lookout, N. Stradbroke Is., Moreton Bay, Qld, on short red algae at low tide, 12 Dec. 1969, coll. W. F. Ponder and P. H. Colman.

ADDITIONAL MATERIAL EXAMINED: Noosa Head, Qld, 2 lots, J. Voorwinde Coll. (1); coll. J. Laseron (3).

DISTRIBUTION AND HABITAT: S. Qld, on algae in lower littoral (fig. 14).

REMARKS: This subspecies is similar in shape to *Rissoella elongatospira* Ponder, 1966 from New Zealand but that species has a slightly broader spire and consequently a larger aperture. The New Zealand species is also pale brown in colour and has a totally different radula which places it in the subgenus *Rissoella (Rissoella).*

The typical subspecies is colourless and transparent, not white, and is slightly smaller in overall size.

Rissoella (Jeffreysiella) fretterae sp. nov.
Figs 2c, d; 9g-i

Shell: Large for genus, with elongate spire, transparent, very pale pinkish or yellowish, thin and fragile. Protoconch usually pink, of 1½ whorls, the apex deviated; teleoconch of up to 5 weakly convex whorls. Aperture simple, lips thin. A minute umbilical chink present, sometimes extremely narrow umbilicus. Smooth except for very fine growth lines (fig. 2c, d).

Dimensions:	Length	Diameter
Holotype	3.46 mm	1.64 mm
Paratype	2.12	1.16
Additional paratype (Deal Is., Tasm.)	2.22	1.22
Figured specimen (Garden Is., W.A.)	1.80	0.90

Animal: Head lacks black pigment (pers. comm. R. Burn from Pt. Lonsdale specimen).

Operculum: Typical (fig. 9g).

Radula: Similar to *R. (Jeffreysiella) wilfredi* but central teeth with only two cusps and a minute denticle on the right side of the median cusp (fig. 9h, i).

Opercula and radulae observed from Gabo Is., Vic. (S.E.M. stub no. 117), Deal Is., N. Tasm. (S.E.M. stub no. 317) and Garden Is., W.A. (S.E.M. stub no. 245).

TYPES: Holotype A.M. (C.101464).
Paratypes A.M. 3(C.102196), 2 (C.102197), 1 shell, 1 operculum and 1 radula on S.E.M. stub no. 117, 1 operculum, 1 radula on S.E.M. stub no. 317.

TYPE LOCALITY: Gabo Is., Vic., on algae, 28 m, Feb. 1973, coll. P. Hutchings.

LOCALITIES OF ADDITIONAL PARATYPES: East Cove, Deal Is., Bass Strait, N. Tasm., 6-15 m, 3-10 May 1974, coll. S. A. Shepherd, S.E.M. stub no. 317 (3 paratypes). Deal Is., Bass Strait, N. Tasm., on algae, 6 m, 6 May 1974, coll. S. A. Shepherd (2 paratypes).

ADDITIONAL MATERIAL EXAMINED: Pt. Lonsdale, Vic., 26 Oct. 1975, coll. R. Burn (1) (N.M.V.). S. of Cowaramup Bay, near Margaret River mouth, S.W.A., in shell sand, coll. H. Baker, pres. J. Hewitt (2, 1 presented to W.A.M.). S.W. end of Garden Is., off Fremantle, W.A., 0-3 m, on algae, 21 Jan. 1972, coll. W. F. and J. M. Ponder and N. Coleman, S.E.M. stub no. 245 (2).

DISTRIBUTION AND HABITAT: Vicinity of Bass Strait and E. Vic. and S.W.A. to mid W.A., on algae in lower littoral (fig. 14).

REMARKS: The shell is very similar in size, shape and colour to *R. (Jeffreysiella) secunda* but has a slightly narrower spire than most specimens of that species. The radula, however, differs in detail and is closest to *R. (Jeffreysiella) wilfredi* but the number of prominent cusps on the central teeth is reduced to 2, not 3 as in *R. (J.) wilfredi.*

This species is named for Dr Vera Fretter for her work on gastropods and, in particular, her detailed account of the anatomy of *Rissoella.*

Rissoella (Jeffreysiella) secunda (Iredale, 1912).
Figs 2e-g; 10a-h.

Heterorissoa secunda Iredale, 1912: 221, text-fig.
Heterorissoa wilfredi. — Iredale, 1924: 245; Laseron, 1950: 286 (non Gatliff and Gabriel, 1911).
Notosetia pellucida Laseron, 1950: 280, fig. 72.
Rissopsis puniceus Laseron, 1950: 283, fig. 82.

Shell: Large for genus, uniform pinkish, pinkish-fawn or pale brown, or with white base and remainder of shell coloured, or white with only adapical end of spire pinkish. Sometimes two broad spiral colour bands on last whorl. Protoconch of 1½ whorls, usually distinctly deviated. Outline of shell variable, whorls of teleoconch convex, up to 4, the last sometimes swollen. Aperture not particularly large (figs 2e-g; 10a, c-e).

Dimensions:	Length	Diameter
Paratype	1.78 mm	0.98 mm
Figured specimens (paratype)	1.84	1.00
Lectotype of *Notosetia pellucida)*	1.30	0.74
(Lectotype of *Rissopsis puniceus)*	3.00	1.50
S.E.M. (Kermadec Ids)	1.72	0.91
(Port Stephens, N.S.W.)	2.84	1.55
	1.76	1.04
(Fairlight, Sydney)	1.24	0.83

Animal: Not observed alive.

Operculum: Typical (figs 10b, f).

Radula: Central teeth with 5-6 cusps, the third or fourth from the left side being the largest. Other details as in *R. (J). wilfredi* (figs 10g, h).

Opercula and radulae observed from New Caledonia (S.E.M. stub no. 162), Lord Howe Island (S.E.M. stub no. 118), Fairlight and Balmoral, Sydney, N.S.W. (S.E.M. stub nos 177, 121), Batemans Bay, N.S.W. (S.E.M. stub no. 239), and an operculum only from the Kermadec Islands (S.E.M. stub no. 160).

TYPES: *H. secunda.* Location of holotype unknown. Not found in British Museum (Nat. Hist.). 2 paratypes A.M. (C.38205, C.102507).

Notosetia pellucida Laseron. Lectotype A.M. (C.101465), here designated, and 11 paralectotypes (C.101466).

Rissopsis puniceus Laseron. Lectotype A.M. (C.101467), and 10 paralectotypes (C.101468).

TYPE LOCALITIES: *H. secunda* Iredale. Raoul (Sunday) Is., Kermadec Ids. *Notosetia pellucida* Laseron. North Harbour, Sydney, N.S.W., on algae. *Rissopsis puniceus* Laseron. Port Stephens, N.S.W., in shell sand.

ADDITIONAL MATERIAL EXAMINED: Raoul (Sunday) Is., Kermadec Ids, 1908-1910, coll. T. Iredale and R. Bell, 3 lots, S.E.M. stub no. 160 (sev). W. side of Ile Signal, off Nouméa, New Caledonia, on algae, 0-2 m, on sandy and dead coral bottom, 25 Apr. 1971, coll. P.H. Colman, S.E.M. stub no. 162 (10/5 w). Lord Howe Is., shore, coll. R. Bell (sev). Lord Howe Is., outside reef, W. of Erscotts Passage, steeply sloping rocky bottom, Feb. 1973, coll. J. Randall, S.E.M. stub no. 118 (sev/9w), Yam Is., Torres Strait, Qld, reef edge on S. side, on *Sargassum*, 6 July 1976, coll. W. F. Ponder and I. Loch (1). Lizard Is., Qld, off Casuarina Beach, on algae in lower littoral on coral rubble, Dec. 1975, coll. W. F. Ponder (sev). Lindeman Is., Qld, J. Voorwinde Coll. (2). Noosa Heads, Qld, J. Voorwinde Coll. (1). Forster, N.S.W., on *Caulerpa*, low tide, open coast, 4 Jan. 1969, coll. W. F. Ponder (1). Forster, N.S.W., J. Voorwinde Coll. (sev). Seal Rocks, N.S.W., J. Voorwinde Coll. (7). Fingal Bay, Port Stephens, N.S.W., in shell sand, 1950-1960, J. Voorwinde Coll., 3 lots (8). Port Stephens, N.S.W. 1950-1960, J. Voorwinde Coll., S.E.M. stub no. 177 (sev/1w). Long Reef, Collaroy, N.S.W., 1950-1960, J. Voorwinde Coll., 4 lots (10). Collaroy Beach, N.S.W., 1950-1960, J. Voorwinde Coll. (1). Manly Beach, Sydney, N.S.W., J. Voorwinde Coll. (4). North Harbour, Sydney, N.S.W., 1950-1960, J. Voorwinde Coll., 3 lots (sev). Fairlight, Sydney, N.S.W., low tide, 23 Dec. 1968, coll. W. F. Ponder, 3 lots, S.E.M. stub no. 177 (4); J. Voorwinde Coll., 5 lots (11). Balmoral, Sydney, N.S.W., on algae, 19 Jan. 1969, coll. W. F. Ponder and J. Voorwinde, S.E.M. stub no. 121 (1). Forty Baskets Beach, Sydney, N.S.W., J. Voorwinde Coll. (sev). Off Sow and Pigs Reef, Sydney, N.S.W., 9 Jan. 1879, coll. J. Brazier, 3 lots (3); J. Voorwinde Coll., 1950-1960, 2 lots (3). Off Chinamans Beach, Sydney, N.S.W., 1968, J. Voorwinde Coll., 2 lots (3). Ocean Beach, Kurnell, Botany Bay, N.S.W., 1950-1960, J. Voorwinde Coll. (2). Werri Beach, N.S.W., in shell sand, 1950-1960, J. Voorwinde Coll. (1). Shell Harbour, N.S.W., on algae, J. Voorwinde Coll. (1). Honeymoon Beach, Jervis Bay, N.S.W., under stones on sandy beach, low tide, 18 Jan. 1969, coll. W. F. Ponder and N. Coleman (1/1w). Inside breakwater, S. side of Ulladulla, N.S.W., on coralline algae, 5 Jan. 1970, coll. W. F. Ponder and P. H. Colman (3/3w). Outside breakwater, S. side of Ulladulla, N.S.W., on coralline algae on moderately exposed rock platform, 5 Jan. 1970, coll. W. F. Ponder and P. H. Colman (1). Ulladulla, N.S.W., in shell sand, 1950-1960, J. Voorwinde Coll., 5 lots (12). On seaward side of long rocky point, Batehaven, Batemans Bay, N.S.W., on red algae, medium exposure, 6 Jan. 1970, coll. W. F. Ponder and P. H. Colman, S.E.M. stub no. 239 (7).

DISTRIBUTION AND HABITAT: Kermadec Islands, New Caledonia, Lord Howe Is., Qld, and N.S.W. on algae in the lower littoral and shallow sublittoral (fig. 14).

REMARKS: There are insufficient differences in the shell to separate representatives of populations throughout the range of this species, including the types of Laseron's species *N. pellucida* and *R. puniceus*. The radulae of specimens from Noumea, New Caledonia, agree exactly with those from Sydney which reinforces the view that only a single species can be recognised. Unfortunately, it has not been possible to examine the radula of a specimen from the Kermadec Islands, the type locality of *R. (J.) secunda*, and, although the shell characters are identical with specimens from other parts of the range of *R. (J.) secunda* (as here recognised) confirmation of the use of this name for populations outside the Kermadec Islands is required. The shell of *R. (J.) secunda* is rather variable in shape and size even within one population. Squat specimens tend to be narrowly umbilicate whereas narrower shells are non-umbilicate. The colour varies from white to yellowish-brown or pinkish, the pink colour sometimes forming 1 or 2 broad spiral bands and is sometimes restricted to the protoconch and the first whorl of the teleoconch.

Rissoella (Jeffreysiella) rissoaformis (Powell, 1939) from New Zealand has a similar shell to *R. (J.) secunda* but the radula differs in having symmetrical central teeth (fig. 6g).

The opportunity is taken to note that at least one undescribed species of *Rissoella* is found at the Kermadec Islands for which, at present, only shells are available (C.102957).

Rissoella (Jeffreysiella) wilfredi (Gatliff and Gabriel, 1911).
Figs 2h-j; 3i; 10i-m.

Jeffreysia wilfredi Gatliff and Gabriel, 1911: 188, pl. 46, fig. 3.
Heterorissoa wilfridi (sic.).— Iredale, 1912: 222.
Jeffreysiella wilfredi.— Macpherson and Gabriel, 1962: 95.

Shell: White, translucent, shining but not glossy. Protoconch white or colourless, of 1½ whorls, often slightly tilted. Teleoconch usually with rapidly increasing whorls of up to 3 in number, the last swollen and usually with a relatively large aperture and short spire. Aperture simple, inner lip thin (figs 2h-j; 10i).

Dimensions:	Length	Diameter
Holotype (from original description)	2 mm	1 mm
Paratype (C.35268)	1.75	1.10
Figured specimens		
(Frederick Henry Bay, S. Tasm.)	1.38	0.95
S.E.M. (Port Fairy, Vic.)	1.72	1.04

Animal: Tentacles long, cephalic tentacles slender and pointed, oral tentacles pointed, with rather broad bases. Head-foot mostly semi-translucent white, sole with median mucous slit. Mantle black or dark grey, head usually with some black pigmentation (Eaglehawk Neck) (fig. 3i) and Point Lonsdale, Vic. (Pers. comm. R. Burn).

Operculum: Typical (fig. 10j).

Radula: Central teeth with straight upper edge, cusps asymmetrical, 2 on right of largest cusp, 1 on left with a row of very small denticles merging with the right basal process which represent the reduced cusps of the right side of the tooth. Lateral teeth with broad bases, the outer portion long, the inner portion short. Median cusp large with many minor cusps on both sides of tooth. Inner marginal teeth similar in shape and cusp formation to lateral teeth except that a prominent outer basal cusp is present on each tooth. Outer marginal teeth simple plates (figs 10k-m).

Opercula and radulae examined from Primrose Pt., S. Tasm. (S.E.M. stub nos 219, 220) and Port Fairy, Vic. (S.E.M. stub no. 171).

TYPES: Holotype N.M.V. (F. 715)
Paratypes (1), N.M.V. (F. 27076), 2 A.M. (C. 35268, C. 45067).

TYPE LOCALITY: Ocean beach, near Pt. Nepean, Vic.

ADDITIONAL MATERIAL EXAMINED: East Cove, Deal Is., Bass Strait, N. Tasm., 6-15 m, 3-10 May 1974, coll. S. A. Shepherd (4). Deal Is., Bass Strait, N. Tasm., on algae, 6 m, 6 May 1974, coll. S. A. Shepherd (4). Murray Pass., Deal Is., Bass Strait, N. Tasm., on algae, 30-50 m, 8 May 1974, coll. S. A. Shepherd (1). Boat Harbour, N. Tasm., on coralline algae in pools, 19 Mar. 1975, coll. W. F. Ponder and R. Kershaw (1). Freestone Cove, Wynyard, N. Tasm., on algae, low tide, 20 Oct. 1971, coll. J. Beu (1). Green Cape, Maria Is., E. Tasm., 5.5 m, 26 Mar. 1970, algae on intertidal rocks, 31 Mar. 1970, coll. W. F. Ponder (2w). Primrose Pt., E. side of Frederick Henry Bay, S.Tasm., low tide, on brown algae, S.E.M. stub nos 219, 220 (3 lots) (8); matted green algae (2), 31 Mar. 1970, coll. W. F. Ponder. Roches Beach, W. side of Frederick Henry Bay, S.Tasm., on coralline algae, semi-sheltered reef, 1 Apr. 1970, coll. W. F. Ponder & E. Turner (sev). Near Granville Harbour, W.Tasm., 23 Nov. 1967, coll. A. Dartnall (1) coll. W. F. Ponder and D. C. Wolfe (2w). Pirates Bay, Eaglehawk Neck, S. Tasm., on brown (T.M.). Between Eagle and Crawfish Rocks, N.W. Arm, Western Port, Vic., 4-5 m, 15 Feb. 1969, coll. W. F. Ponder and B. J. Smith (1w). San Remo and Shoreham, Vic., Gatliff Coll. (9) (N.M.V.). Shoreham, Vic., Gabriel Coll. (5) (N.M.V.). Pt. Nepean, Vic., ex. Gatliff Coll. (1) (N.M.V.). Pt. Lonsdale, Vic., on short algae, exposed edge of platform, 22 Mar. 1975, coll. W. F. Ponder and R. Burn (1); coll. R. Burn (2) (N.M.V.). Port Fairy, Vic., 4 km W. of town, on coralline algae, 19 Mar. 1973, coll. W. F. Ponder and R. Burn, S.E.M. stub no. 171. Off Middle Pt., near Cape Northumberland, S.A., on algae, 13 m, 19 Mar. 1974, coll. S. A. Shepherd (3). Robe, S.A., J.C. Verco Coll. (3) (S.A.M.). Mississippi Bay, 48 km E. of Esperance, S.W.A., on algae, 0-2 m, 6 Feb. 1972, coll. W. F. Ponder (1). E. side of Hopetoun Jetty, S.W.A., on algae, W. side of sheltered limestone reef, 0-1 m, 4 Feb. 1972, coll. W. F. and J. M. Ponder (1).

DISTRIBUTION AND HABITAT: Bass Strait, Tasm., Vic., S.A. and southernmost S.W.A., on algae in the lower littoral and sublittoral (fig. 14).

REMARKS: Differs from *R. (J.) secunda* and *R. (J.) fretterae* in its smaller size, more rapidly increasing and fewer whorls and its uniform white colour. The material examined has consisted of small numbers but these appear to be fairly constant over the range of the species. *Rissoella (J.) wilfredi* and *R. (J.) fretterae* probably occur sympatrically along most of the southern Australian coast although they have only been obtained together from two localities (Deal Is., Bass Strait and Point Lonsdale, Victoria).

Some specimens examined from Tasmania show considerable variation in shape, some being narrow like *R. (J.) secunda*, but are consistent in their uniformly white coloration and smaller size than *R. (J.) secunda* as well as in exhibiting the radular features of *R. (J.) wilfredi*.

ACKNOWLEDGEMENTS

We are indebted to the persons and institutions that have kindly made material available for this study or have collected samples. We would also like to thank Miss Diane Higginbotham of the Sydney University Electron Microscope Unit and Mr P. E. Schwerin for his assistance with the translation of German texts. Dr F. Climo of the National Museum of New Zealand and Mr. A. Warén of the Zoologiska Institutionen, Göteborgs Universitet kindly provided specimens of *R. micra* and *R. globularis* respectively. This work was supported in large part by a grant from the Australian Research Grants Committee (D1-70/17338).

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Fig. 1.

a. *Rissoella (Rissoella) atrimacula* sp. nov., Yallingup, S.W.A., holotype, A.M. (C.99655). 1.52 mm × 1.06 mm.

b. *R. (R.) fallax* sp. nov., Fairlight, North Harbour, Sydney, N.S.W., holotype, A.M. (C.101418). 1.02 mm × 0.77 mm.

c. *R. (R.) globosa* sp. nov., Heron Is., Qld, holotype, A.M. (C.101424). 1.12 mm × 0.80 mm.

d. *R. (R.) vitrea* sp. nov., Denham, Shark Bay, W.A., holotype, A.M. (C.101428). 0.95 mm × 0.65 mm.

e. *R. (R.) vitrea* sp. nov., W. side of Thevenard, S.A., A.M. (C.101478). 0.86 mm × 0.62 mm.

f. *R. (R.) vitrea* sp. nov., N. of Snapper Pt., Aldinga, S.A., A.M. (C.101479). 1.30 mm × 0.94 mm.

g. *R. (Jeffreysilla) confusa confusa* subsp. nov., Lizard Is., Qld, holotype, A.M. (C.101430). 1.50 mm × 0.96 mm.

h. *R. (J.) confusa robertsoni* subsp. nov., S. side of Ulladulla, N.S.W., holotype, A.M. (C.101452). 1.00 mm × 0.67 mm.

i *R. (J.) confusa umbilicata* subsp. nov., Mississippi Bay, 48 km E. of Esperance, S.W.A., holotype, A.M. (C.101454). 1.22 mm × 0.78 mm.

j. *R. (J.) confusa umbilicata* subsp. nov., off Dunsborough, S.W.A., A.M. (C.101480). 1.08 mm × 0.74 mm.

k. *R. (Zelaxitas) imperforata* sp. nov., Pirates Bay, Eaglehawk Neck, S. Tasm., holotype, A.M. (C.101457). 1.00 mm × 0.75 mm.

l. *R. (Z.) micra* (Finlay), lectotype of *Notosetia fulva* Laseron, Long Reef, Sydney, N.S.W., A.M. (C.101459). 1.20 mm × 0.88 mm.

m. *R. (Z.) micra* (Finlay), Fairlight, North Harbour, Sydney, N.S.W., A.M. (C.101482). 0.95 mm × 0.70 mm.

n. *R. (Z.) micra* (Finlay), Smugglers Bay, Whangarei Heads, New Zealand, A.M. (C.101481). 0.80 mm × 0.60 mm.

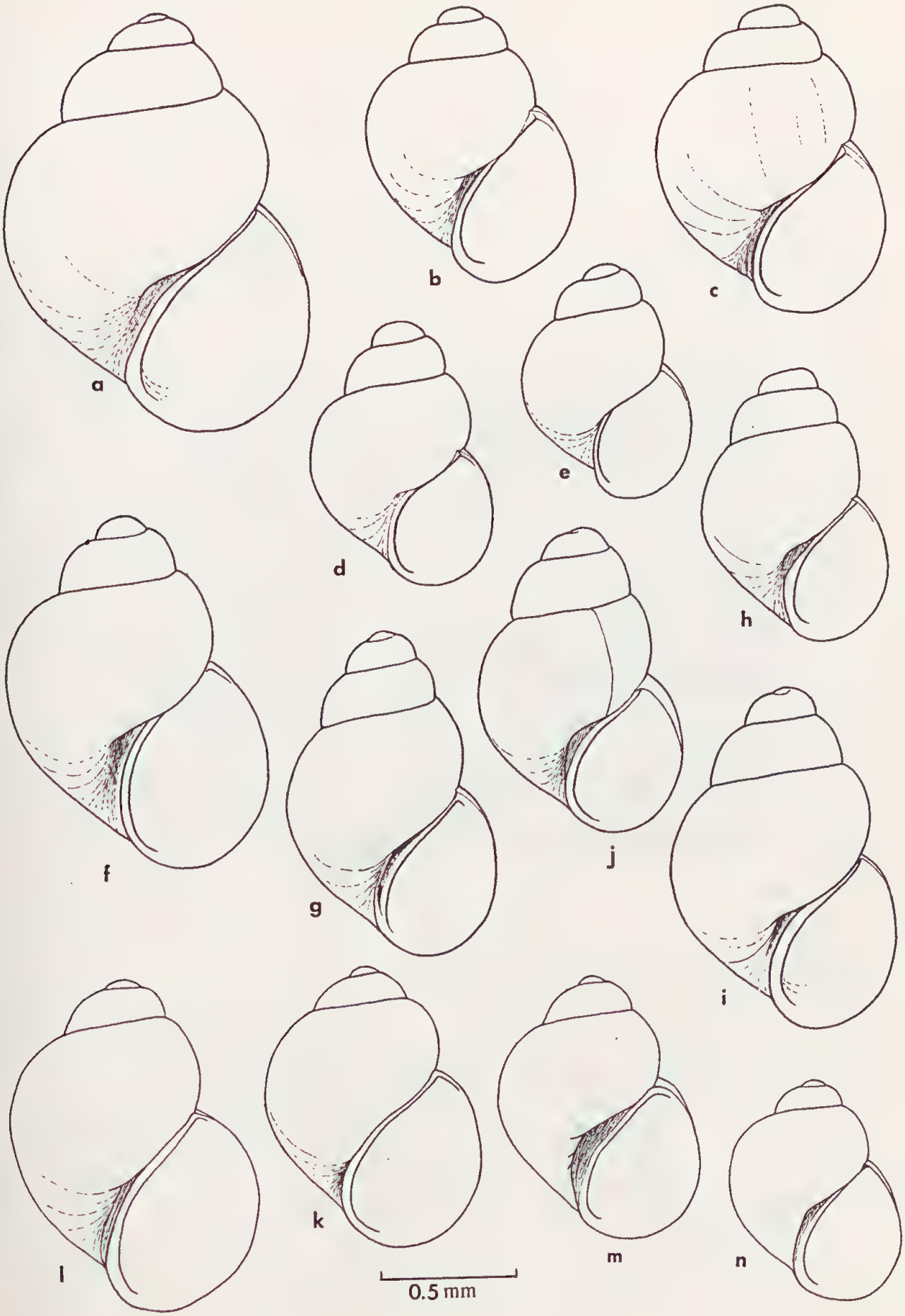
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Fig. 2.

a. *Rissoella (Jeffreysiella) colleenae colleenae* subsp. nov., Twilight Cove, 6 km W. of Esperance, S.W.A., holotype, A.M. (C.100000). 0.93 mm × 0.54 mm.

b. *R. (J) colleenae pacifica* subsp. nov., N.W. side of Pt. Lookout, Stradbroke Is., Moreton Bay, Qld, holotype, A.M. (C.101461). 1.10 mm × 0.55 mm.

c. *R. (J.) fretterae* sp. nov., Gabo Is., Mallacoota, Vic., holotype, A.M. (C.101464). 3.46 mm × 1.64 mm.

d. *R. (J.) fretterae* sp. nov., S.W. end of Garden Is., S.W. of Perth, W.A., A.M. (C.101463). 1.80 mm × 0.90 mm.

e. *R. (J.) secunda* (Iredale), lectotype of *Notosetia pellucida* Laseron, North Harbour, Sydney, N.S.W., A.M. (C.101465). 1.30 mm × 0.74 mm.

f. *R. (J.) secunda* (Iredale), lectotype of *Rissopsis puniceus* Laseron, Port Stephens, N.S.W., A.M. (C.101467). 3.00 mm × 1.50 mm.

g. *R. (J.) secunda* (Iredale), Raoul (Sunday) Is., Kermadec Ids, paratype, A.M. (C.38205). 1.84 mm × 1.00 mm.

h. *R. (J.) wilfredi* (Gatliff and Gabriel), Ocean beach, near Pt. Nepean, Vic., holotype, N.M.V. (F. 715). 2 mm × 1 mm.

i, j. *R. (J.) wilfredi* (Gatliff and Gabriel), Roches Beach, W. side of Frederick Henry Bay, S. Tasm., A.M. (C.101483). i. 1.38 mm × 0.95 mm, j. 1.34 mm × 0.82 mm.

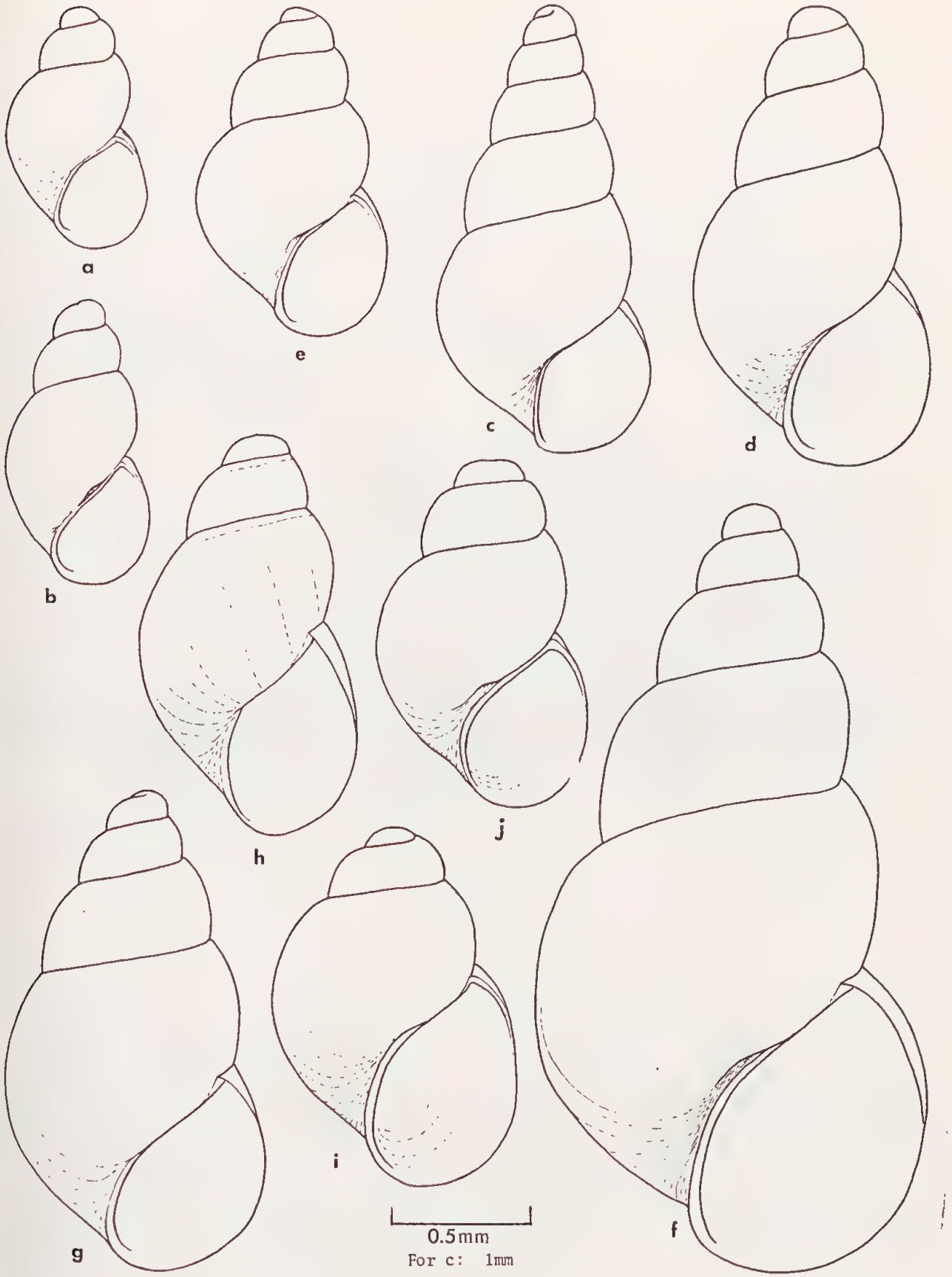
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Fig. 3. Semi-diagrammatic dorsal views of head.

a. *Rissoella (Rissoella) atrimacula* sp. nov., Yallingup, S.W.A.
b. *R. (R.) fallax* sp. nov., Pirates Bay, Eaglehawk Neck, S. Tasm.
c. *R. (R.) globosa* sp. nov., Heron Is., Qld.
d. *R. (R.) vitrea* sp. nov., N. of Snapper Pt., Aldinga, S.A.
e. *R. (Jeffreysilla) confusa confusa* subsp. nov., Lizard Is., Qld.
f. *R. (Zelaxitas) imperforata* sp. nov., Pirates Bay, Eaglehawk Neck, S. Tasm.
g. *R. (Z.) micra* (Finlay), Fairlight, Sydney, N.S.W.
h. *R. (Jeffreysiella) colleenae pacifica* subsp. nov., N.W. side of Point Lookout, N. Stradbroke Is., Qld.
i. *R. (J.) wilfredi* (Gatliff and Gabriel), Eaglehawk Neck, S. Tasm.

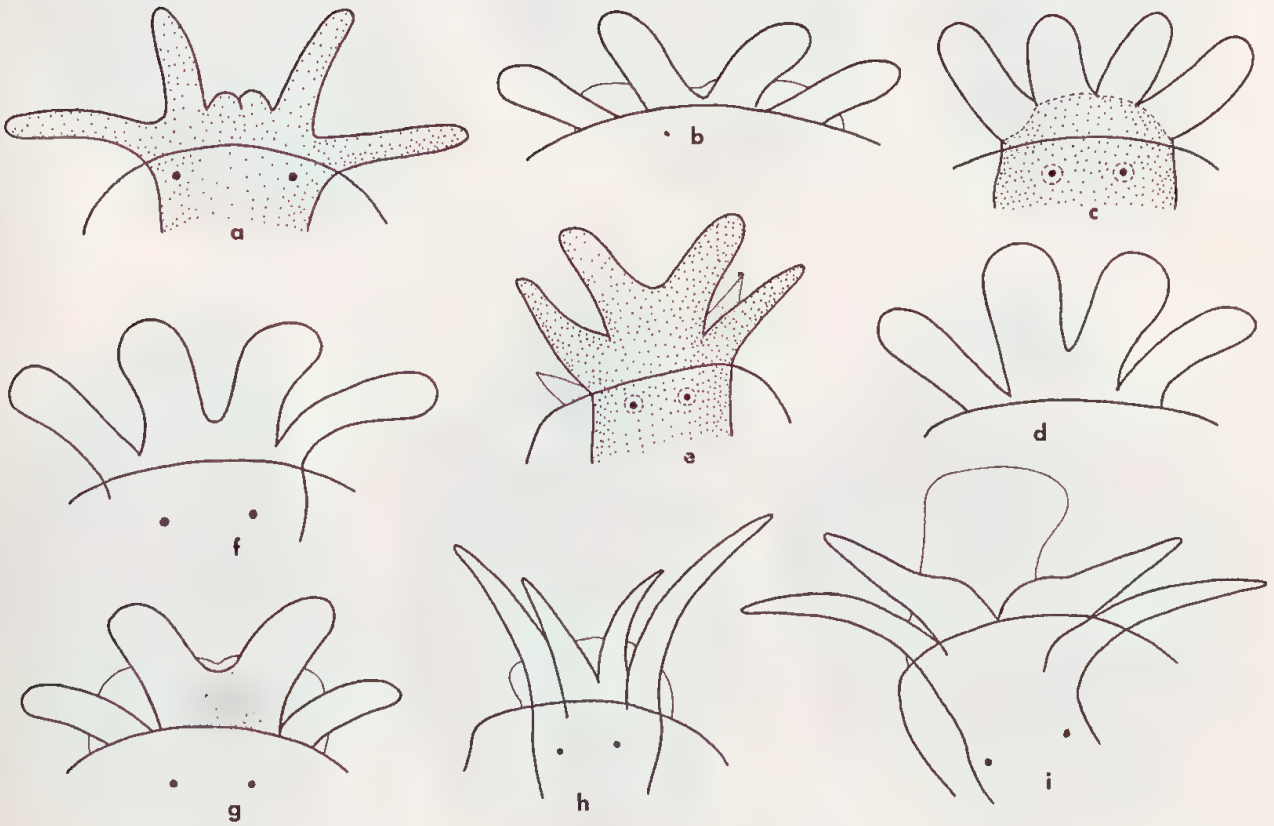
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Fig. 4
Rissoella (Rissoella) atrimacula sp. nov.

a. Shell — 1.47 mm × 1.07 mm, Yallingup, S.W.A., S.E.M. stub no. 111.

b. Shell — 1.07 mm × 0.80 mm, c. Operculum — X100, North Pt., Rottnest Is., W.A., S.E.M. stub no. 115.

d. Operculum — X100, e. Radula — X1000, Hopetoun Jetty, S.W.A., S.E.M. stub no. 198.

R. (R.) fallax sp. nov.

f. Shell — 0.98 mm × 0.72 mm, Fairlight, Sydney, N.S.W., S.E.M. stub no. 204.

g. Operculum — X110, h. Radula — X1100, Wimbie Beach, Batemans Bay, N.S.W., S.E.M. stub no. 232.

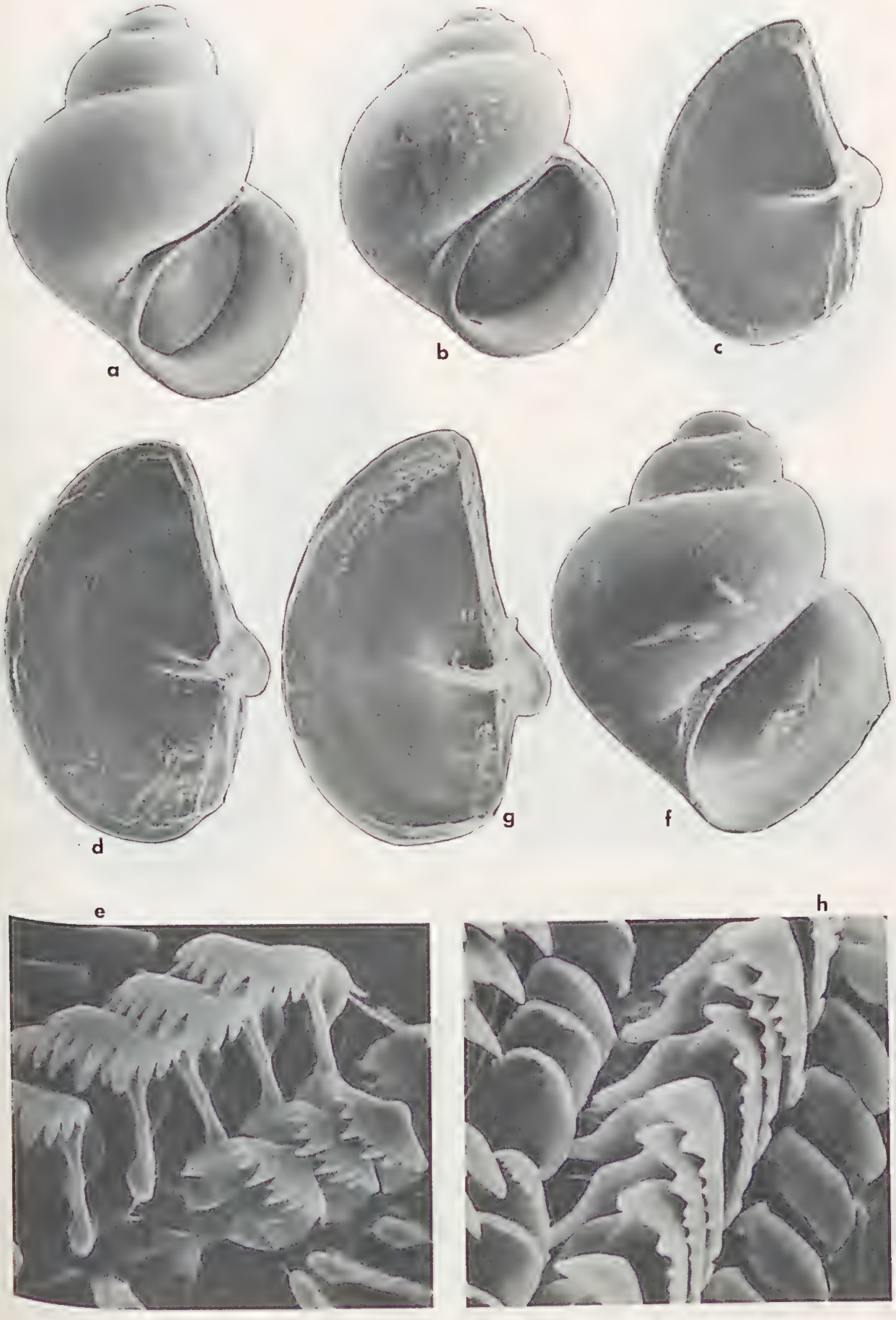
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Fig. 5
Rissoella (Rissoella) globosa sp. nov.

a. Shell — 0.95 mm × 0.74 mm, b. Operculum — X130, Heron Is., Qld, S.E.M. stub no. 197.

c. Shell — 0.92 mm × 0.72 mm, N. side of Rabbit Is., Lord Howe Is., S.E.M. stub no. 119.

d. Shell — 1.22 mm × 0.90 mm, e. Operculum — X130, f. Radula — X1000, Nouméa, New Caledonia, S.E.M. stub no. 164.

g. Radula — X1300, h. Radula X3000, Heron Is., Qld, S.E.M. stub no. 197.

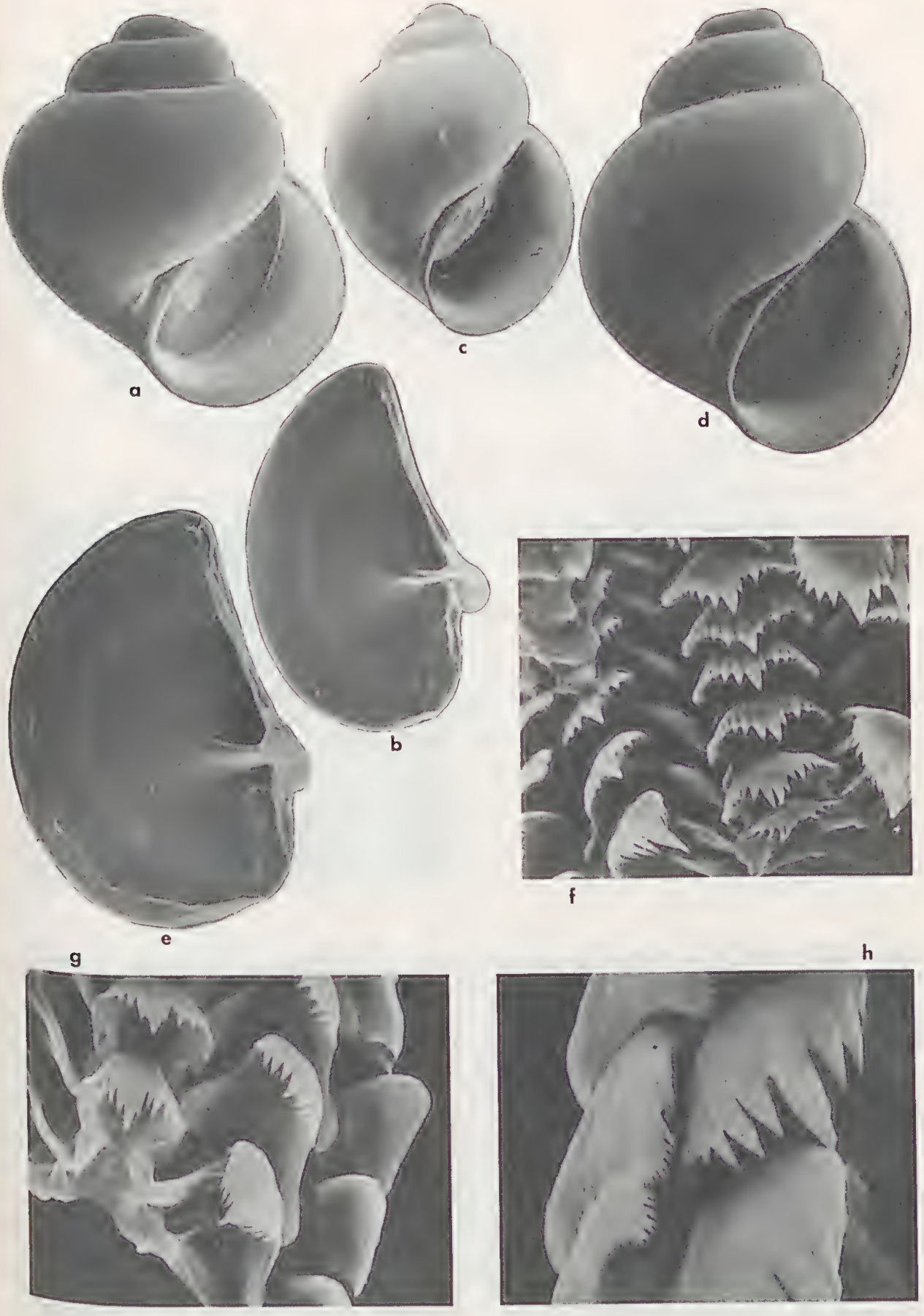
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Fig. 6.
Rissoella (Rissoella) vitrea sp. nov.

a. Shell — 0.88 mm × 0.62 mm, W. side of Thevenard, S.A., S.E.M. stub no. 244.

b. Shell — 1.40 mm × 0.95 mm, North Pt., Rottnest Is., W.A. S.E.M. stub no. 114.

c. Shell — 0.93 mm × 0.62 mm, d. Operculum — X180, e. Radula — X1300, Denham, Shark Bay, W.A., S.E.M. stub no. 112.

f. Radula — X1000, N. of Snapper Pt., Aldinga, S.A., S.E.M. stub no. 231.

R. (Jeffreysiella) rissoaformis (Powell)

g. Radula — X740, Island Bay, Wellington, New Zealand, S.E.M. stub no. 206.

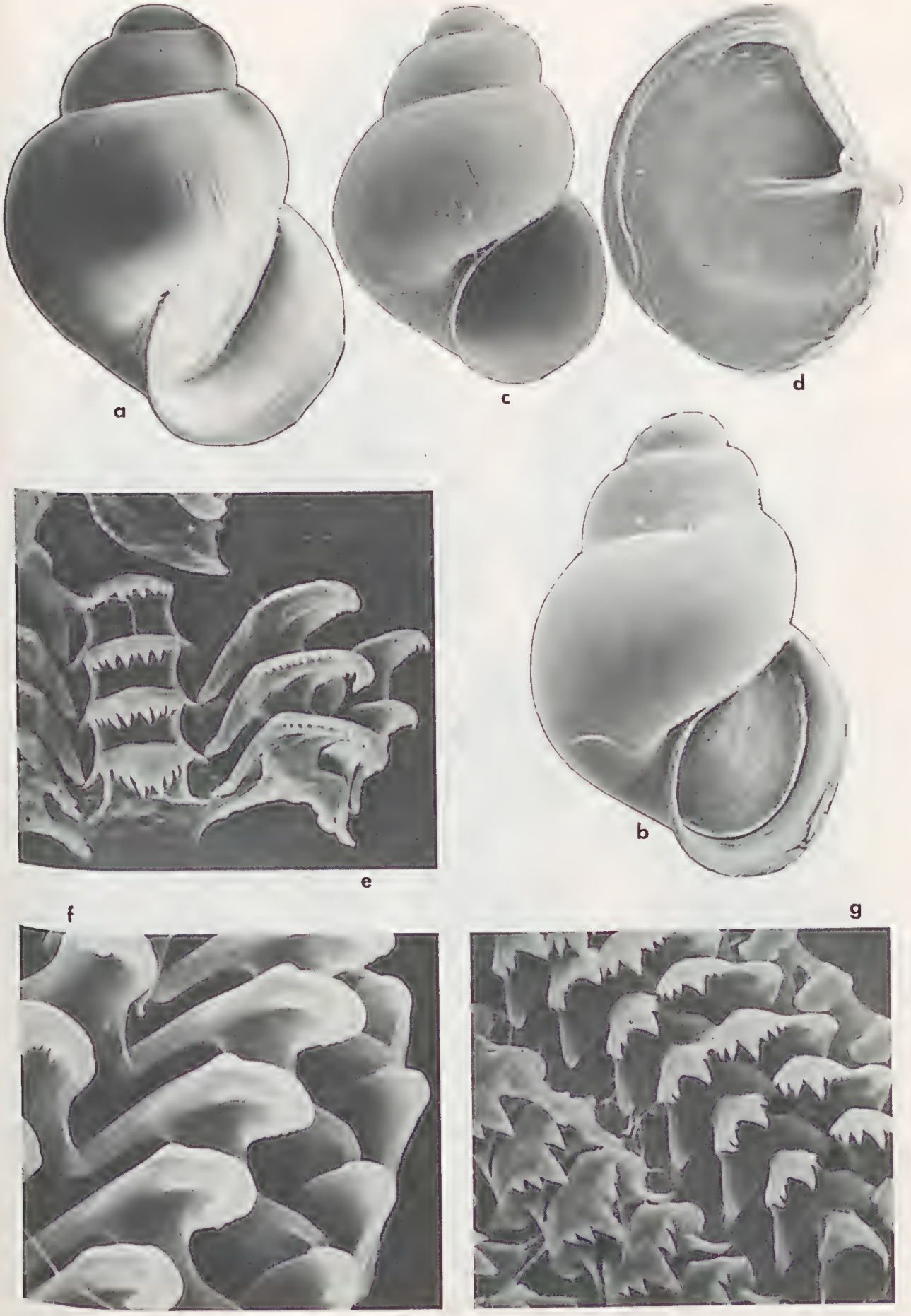
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Fig. 7.
Rissoella (Jeffreysilla) confusa confusa subsp. nov.

a. Shell — 1.16 mm × 0.75 mm, b. Operculum — X140, Nouméa, New Caledonia, S.E.M. stub no. 163.

c. Shell — 1.02 mm × 0.69 mm, Tanna Is., New Hebrides, S.E.M. stub no. 120.

d. Shell — 1.00 mm × 0.68 mm, Lizard Is., Qld, S.E.M. stub no. 226.

e. Radula — X1500, Lizard Is., Qld, S.E.M. stub no. 202.

R. (J.) confusa umbilicata subsp. nov.

f. Shell — 1.04 mm × 0.73 mm, g. Operculum — X150, h. Radula — X1500, Hopetoun Jetty, S.W.A., S.E.M. stub no. 199.

i. Shell — 1.31 mm × 0.87 mm, Mississippi Bay, S.W.A., S.E.M. stub no. 147.

j. Operculum — X160, Off Dunsborough, S.W.A., S.E.M. stub no. 167.

k. Radula — X3300, Off Dunsborough, S.W.A., S.E.M. stub no. 122.

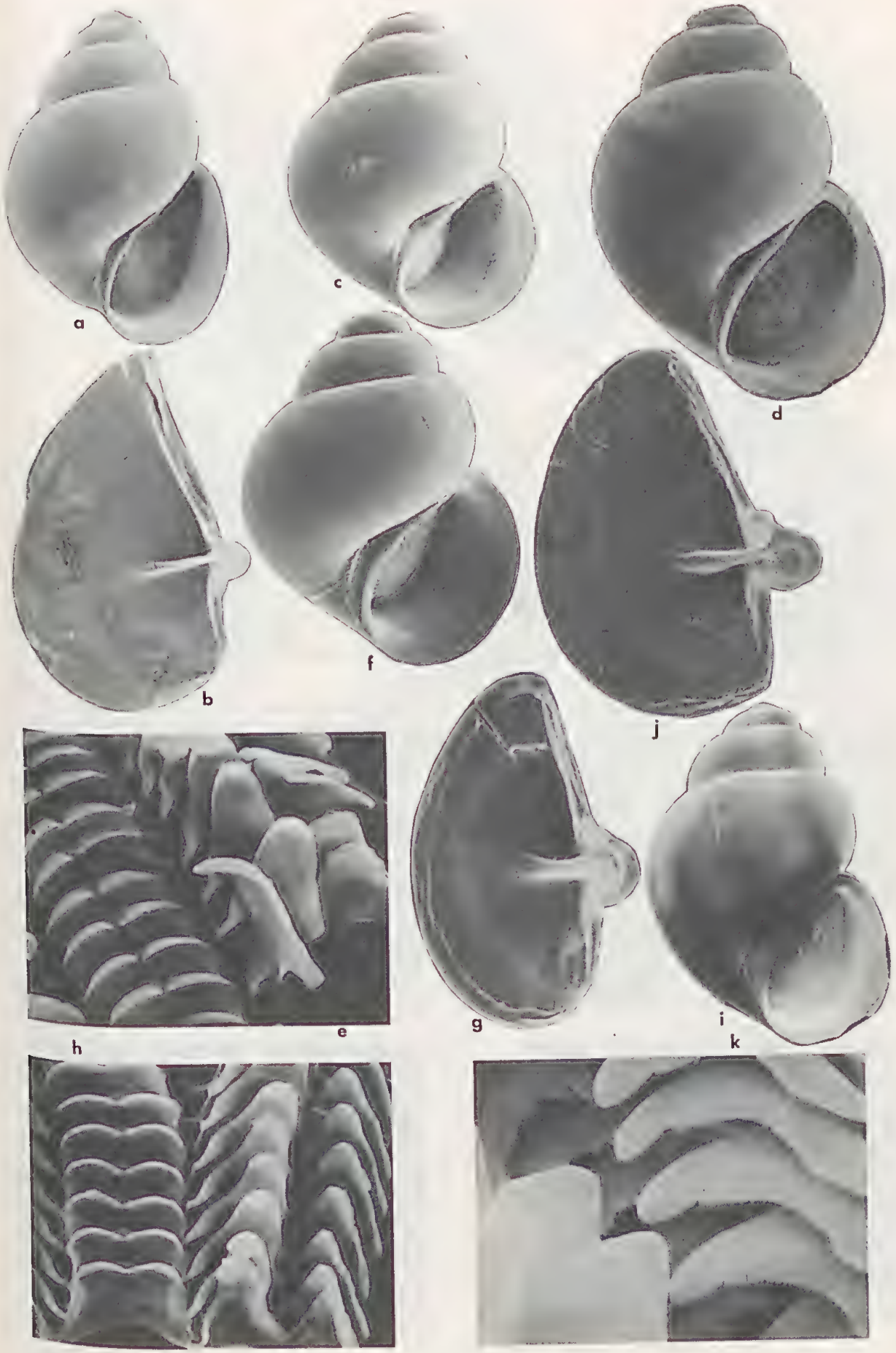
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Fig. 8.
Rissoella (Zelaxitas) imperforata sp. nov.

a. Shell — 0.94 mm × 0.74 mm, Pirates Bay, Eaglehawk Neck, S. Tasm., S.E.M. stub no. 116.

b. Radula — X800, Pirates Bay, Eaglehawk Neck, S. Tasm., S.E.M. stub no. 222.

R. (Z.) micra (Finlay).

c. Shell — 1.10 × 0.76 mm, d. Shell — 0.86 mm × 0.68 mm, e. Operculum — × 150, Fairlight, Sydney, N.S.W., S.E.M. stub nos 113, 200.

f. Shell — 1.10 mm × 0.84 mm, g. Radula — X800, Island Bay, Wellington, New Zealand, S.E.M. stub no. 210.

h. Radula — X1200, Primrose Pt., E. side Frederick Henry Bay, S. Tasm., S.E.M. stub no. 221.

i. Radula — X1300, Long Reef, Sydney, N.S.W., S.E.M. stub no. 201.

R. (Z.) cystophora (Finlay)

j. Shell — 0.86 mm × 0.64 mm, Island Bay, Wellington, New Zealand, S.E.M. stub no. 169.

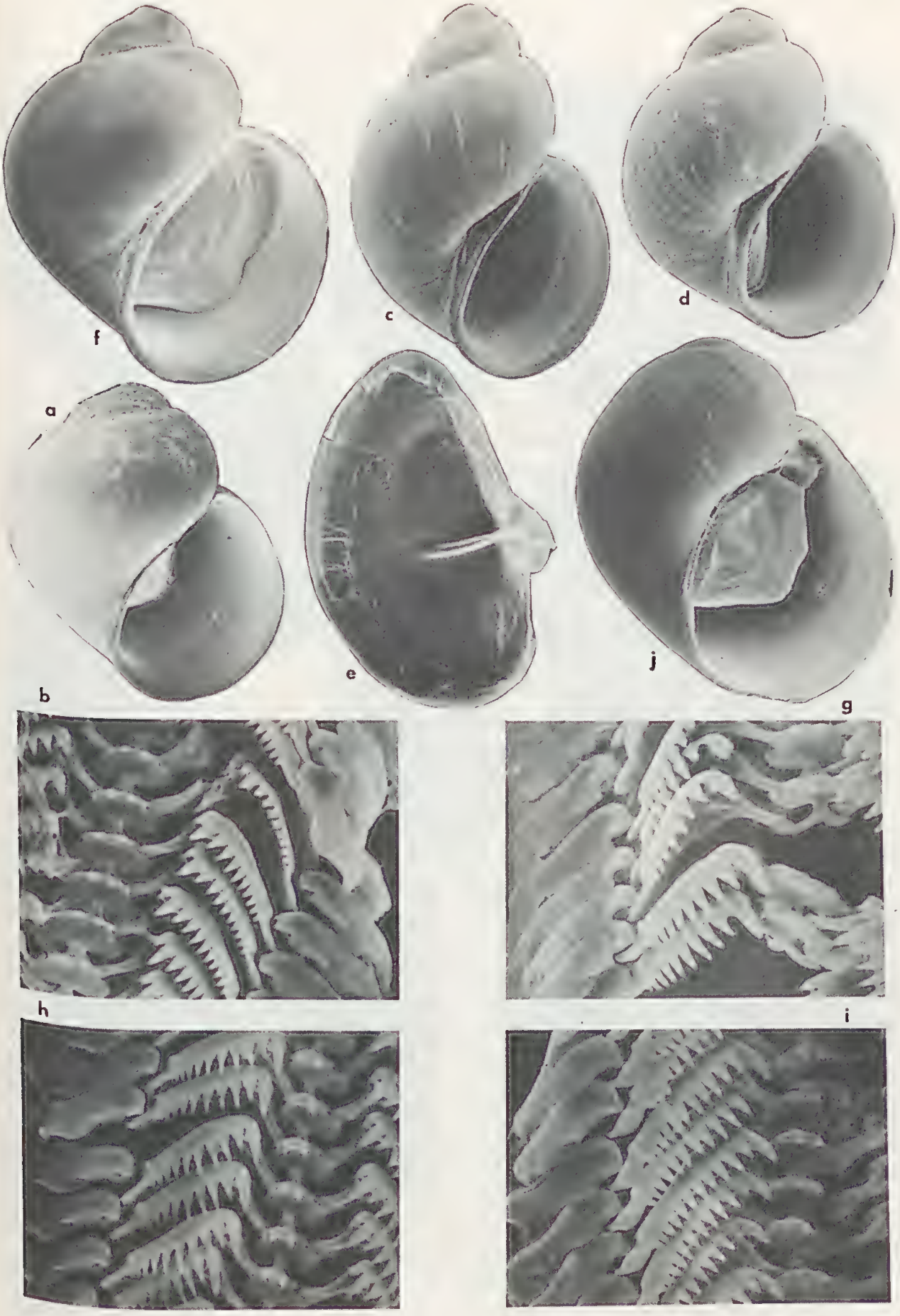
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Fig. 9.
Rissoella (Jeffreysiella) colleenae colleenae subsp. nov.

a. Shell — 0.93 mm × 0.52 mm, b. Operculum — X140, c. Radula — X1200, Twilight Cove, 6 km E. of Esperance, S.W.A., S.E.M. stub no. 203.

R. (J.) colleenae pacifica subsp. nov.

d. Shell—1.24 mm × 0.64 mm, e. Operculum — X140, f. Radula — X1200, N.W. side of Pt. Lookout, N. Stradbroke Is., Qld, S.E.M. stub no. 191.

R. (J.) fretterae sp. nov.

g. Operculum — X90, h. Radula — X700, i. Radula — X1600, S.W. end of Garden Is., off Fremantle, W.A., S.E.M. stub no. 245.

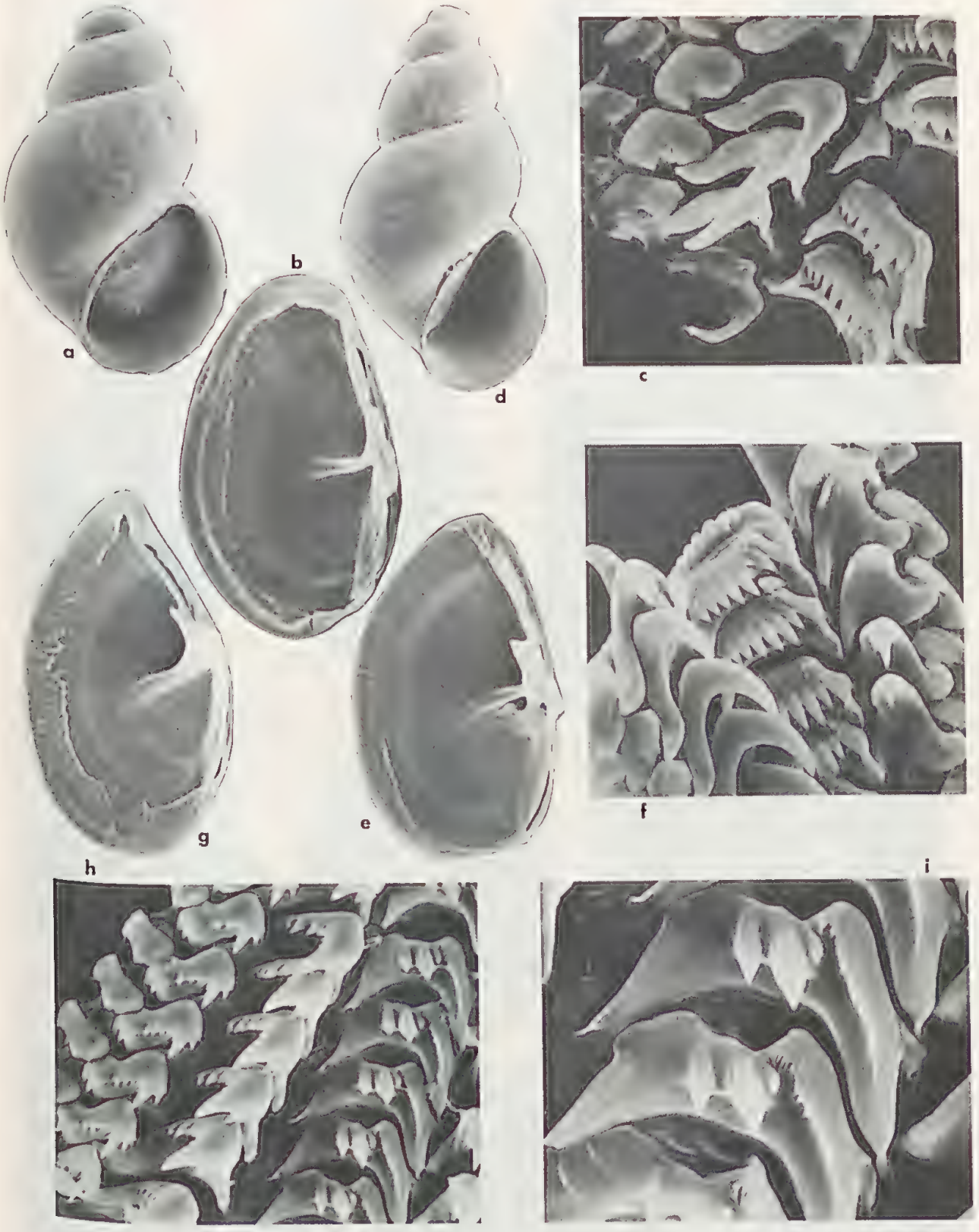
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Fig. 10.
Rissoella (Jeffreysiella) secunda (Iredale)

a. Shell — 1.72 mm × 0.91 mm, b. Operculum X100, Raoul Is., Kermadec Ids, S.E.M. stub no. 160.

c. Shell — 2.84 mm × 1.55 mm, d. Shell — 1.76 mm × 1.04 mm, Port Stephens, N.S.W., S.E.M. stub no. 177.

e. Shell — 1.24 mm × 0.83 mm, f. Operculum — X70, g. Radula — X900, h. Radula — X560, Fairlight, Sydney, N.S.W., S.E.M. stub no. 177.

R. (J.) wilfredi (Gatliff and Gabriel)

i. Shell — 1.72 mm × 1.04 mm, j. Operculum — X90, k. Radula — X 00, l. Radula — X1000 m. Radula — X600, Port Fairy, Vic., S.E.M. stub no. 171.

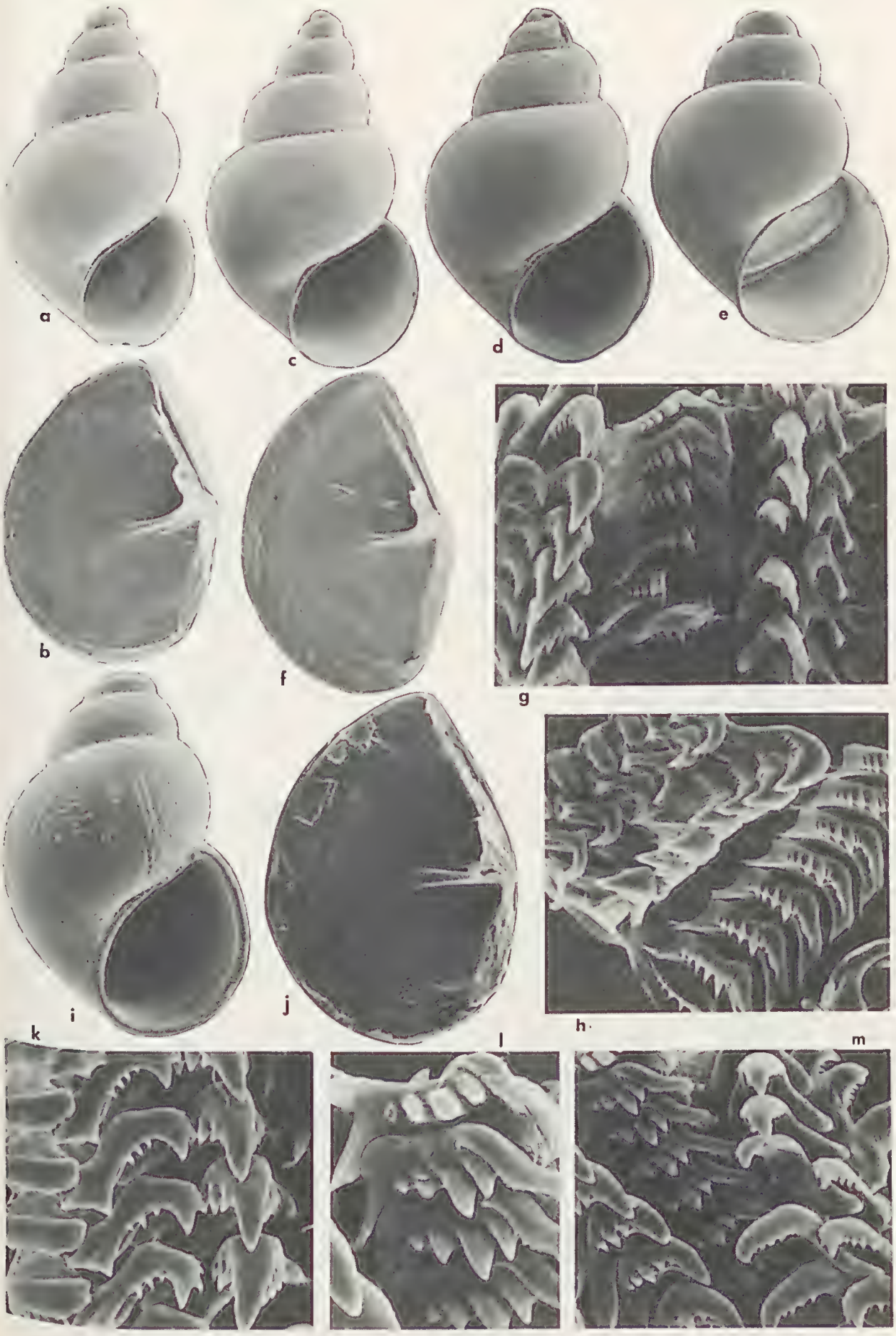
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Fig. 11. Distribution of Rissoella (Rissoella) species.

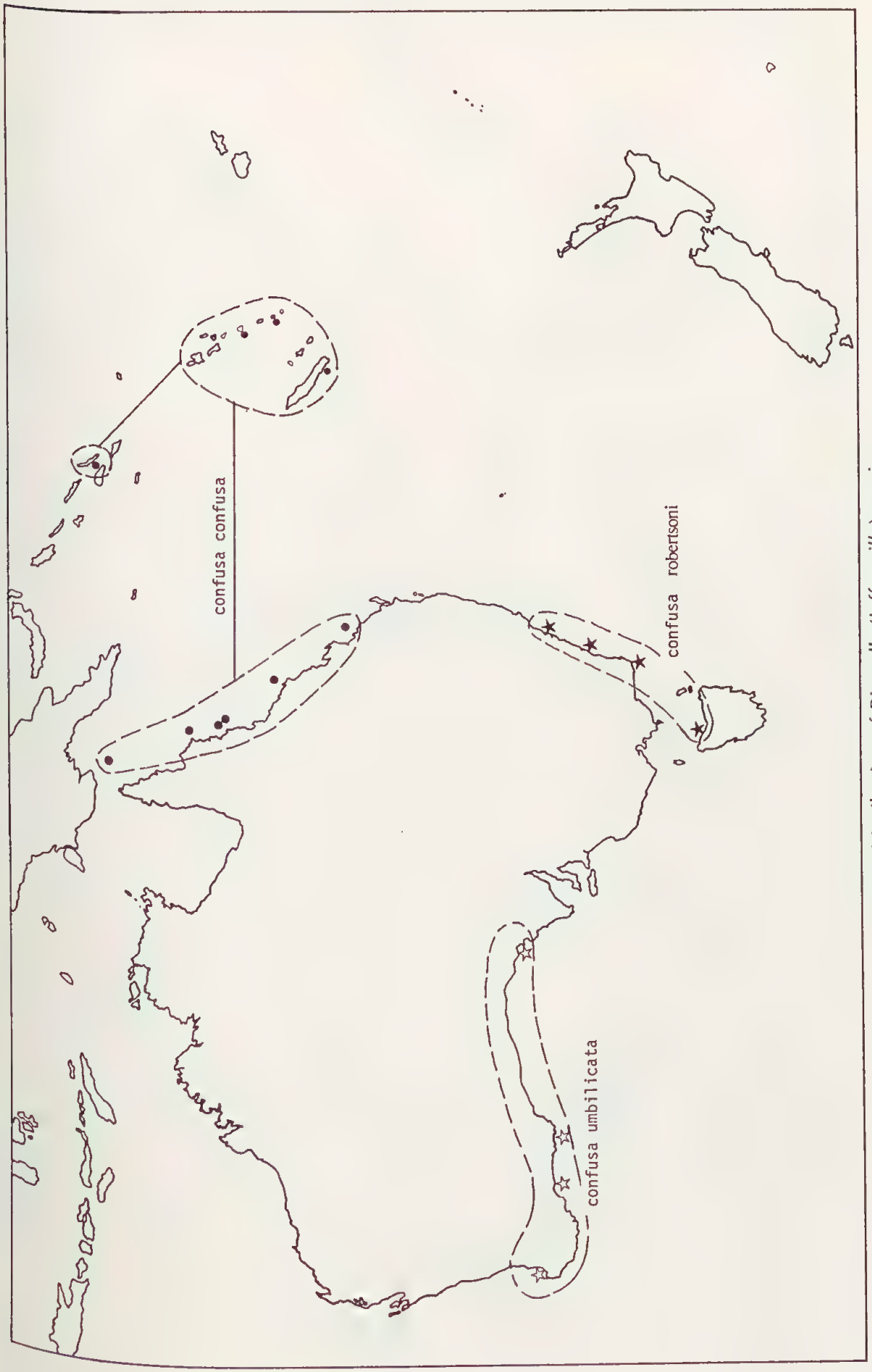

Fig. 12. Distribution of *Rissoella* (*Jeffreysilla*) species.

Fig. 13. Distribution of Rissoella (Zelaxitas) species.

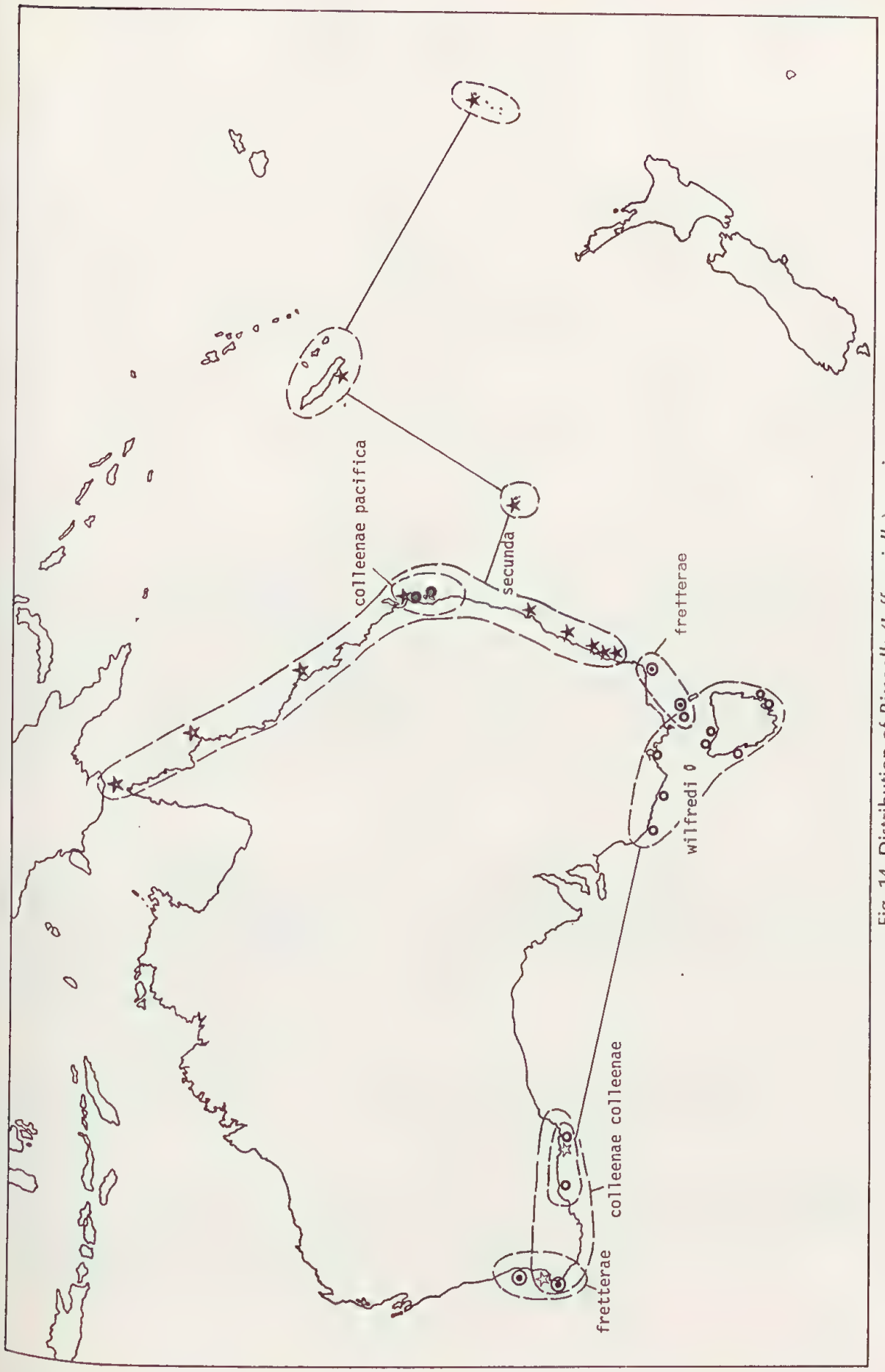

Fig. 14. Distribution of *Rissoella (Jeffreysiella)* species.

A NEW FAMILY OF ASTEROIDEA (ECHINODERMATA), WITH THE DESCRIPTION OF FIVE NEW SPECIES AND ONE NEW SUBSPECIES OF *ASTERODISCIDES*.

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SUMMARY

The genera *Asterodiscides* A. M. Clark, *Paulia* Gray and *Amphiaster* Verrill are compared and assigned to a new family. The relationship between *Paulia* and *Pauliella* is discussed. Five new species and one new subspecies are described for the genus *Asterodiscides* with the holotype of the type-species, *Asterodiscus elegans* Gray, being fully described for the first time. *Asterodiscus hiroi* Hayashi is considered to be conspecific with *A. helenotus* (Fisher) and two juvenile specimens of the species are described. Examination of many juvenile specimens has allowed an assessment to be made of the relative constancy of form of the various structural elements used in determining specific limits within the family. A key is given to the genera and species of the family.

INTRODUCTION

Gray (1840) established a monotypic genus, *Paulia,* in the family Pentacerotidae, for the species *P. horrida,* which was collected from Punta Santa Elena, Ecuador. Later (1847) he described another monotypic genus, *Asterodiscus,* for the species *A. elegans,* from an unknown locality (probably the Philippines, see Clark and Rowe, 1971 p. 40). Gray (1866) considered both of his genera related at family level, placing them together in the family Pentacerotidae.

Müller and Troschel (1842) grouped several of Gray's genera, including *Paulia,* in their embracing genus *Goniodiscus.*

Verrill (1868) described the monotypic genus *Amphiaster* with *A. insignis* from La Paz, Lower California, comparing it with the genera *Oreaster* and *Nidorellia* in the family Pentacerotidae.

Perrier (1875) restricted Müller and Troschel's genus *Goniodiscus.* He recognised Gray's *Asterodiscus,* but considered *Paulia* a synonym of *Nidorellia.* Perrier included *Asterodiscus elegans* and *Paulia horrida* (as *Nidorellia horrida*) in the family Goniasteridae. He re-described Gray's type specimen of *P. horrida.*

Records of The Australian Museum, 1977, **Vol. 31 No. 5,** 187-233, Figures 1-5

Viguier (1878), classifying the Asteroidea (Stellérides) on skeletal features, placed *Asterodiscus*, with *Goniaster, Goniodiscus, Anthenea, Nectria, Culcita, Choriaster, Nidorellia, Pentaceros* and *Gymnasteria*, in the family Goniasteridae, tribe Goniasterinae. He separated a second tribe, Pentagonasterinae (including *Pentagonaster, Hippasteria, Ferdina, Fromia* and *Metrodira*) on the lack of 'systèmes interbrachiaux; pas de spicules dans les ambulacres'. He clearly did not dissect the only specimen of *Asterodiscus* available to him (Paris Museum) but considered it closely related to *Culcita* because of its shape. He did not deal with *Amphiaster* and treated *Paulia* as a synonym of *Nidorellia*.

Perrier (1884), classifying the Asteroidea according to the form of the pedicellariae, recognised four orders and placed *Asterodiscus* in the order Valvatae (Valvulatae), family Pentacerotidae (together with *Pentaceros, Nidorellia, Culcita* and *Choriaster* — a restriction of Viguier's Goniasterinae). He, like Viguier, did not mention *Amphiaster*.

Sladen (1889) dismissed Viguier's and Perrier's classifications in favour of reliance on the distribution of papulae and the characters of the ambulacral and marginal plates. He recognised two orders, Phanerozonia and Cryptozonia, placing *Asterodiscus, Paulia* and *Amphiaster* in the Phanerozone family Pentacerotidae. He considered this to be a discrete group having unequally developed marginal plates, superomarginals often hidden under a membrane, a reticulate skeleton, plates with large, isolated tubercles or spinelets, granulose or covered with a membrane and actinal interradial areas with large pavement-like plates bearing unequal-sized granules. He recognised Perrier's Pentagonasteridae, Antheneiidae and Gymnasteriidae as distinct from the Pentacerotidae, using his own system.

Ludwig (1889) following Perrier and Sladen, merely recorded *Asterodiscus, Amphiaster* and *Paulia* in the family Pentacerotidae. In 1905 Ludwig described the monotypic genus *Pauliella* in the same family. The species *P. aenigma* was based on two small specimens with R = 13.5 and 16.5 mm from Cocos Islands (Pacific). He gave an exhaustive description of both *Paulia horrida* var. *galapagensis* (a new variety) and *Pauliella aenigma*. He clearly showed the spaced marginals in *Paulia* as well as other diagnostic features, but thought that *P. aenigma* might prove to represent the juvenile form of *Paulia*. *P. aenigma* has not been recorded since it was first described.

Fisher (1906) described a new species, *Asterodiscus tuberculosus*, from Hawaii, classifying it in the family Pentacerotidae. In 1911 he described the family Oreasteridae in a key. In the same publication he included *Amphiaster* in the sub-family Goniasterinae of the family Goniasteridae. He did not classify *Paulia* or *Asterodiscus* at that time. Fisher (1911) had, in fact, merged Perrier's Valvata and Paxillosa into Sladen's Phanerozonia, but dropped Cryptozonia in favour of Perrier's Spinulosa and Forcipulata. He did this by combining the characters used by Sladen and Perrier and, in fact, Viguier, though he did not credit Viguier.

In 1914 Verrill included *Amphiaster* in his sub-family Goniasterinae (Verrill, 1899), though this name had been used previously by Viguier (1878). At no time does it appear that Verrill was aware of (or at least did not take into account) Viguier's work.

Fisher (1919) indicated that the name Oreasteridae replaced the untenable name Pentacerotidae and included *Asterodiscus* in that family when he described another new species, *A. helenotus*.

Boone (1928) clearly follows Fisher's classification of *Amphiaster*.

Döderlein (1935) reviewed the families Pentagonasteridae (= Goniasteridae (Goniasterinae), see Fisher, 1911) and Oreasteridae when he examined the 'Siboga' material. He concluded that *Asterodiscus* should be removed from the Oreasteridae and placed in the Pentagonasteridae. He justified this move mainly on the absence of a calcareous interbrachial partition and lack of spicules in the disc of the tube-feet. Both of these features, he considered were very important in distinguishing the two families. He did not mention Viguier's work but seemed to be following a similar line of reasoning.

Döderlein did not deal with *Amphiaster* but retained *Paulia* in the Oreasteridae. He could not have examined any specimens of either of those two genera. In 1936 he listed *Pauliella aenigma* as a synonym of *Paulia horrida* in the family Oreasteridae.

H. L. Clark (1946) merely considered that *Asterodiscus* was more probably an oreasterid and was prepared to believe Fisher rather than Döderlein.

Spencer and Wright (1966) adopted a combination of Perrier's and Viguier's classification of asteroids, but in a modified form, this being based, they considered, 'on recent palaeontological evidence'. It is obvious, however, that the features stressed by Sladen also played a large part in their classification. They listed *Paulia* (with *Pauliella* as a synonym) and *Asterodiscus* in the family Oreasteridae, but included *Amphiaster* in a list of genera belonging to an unknown subfamily of the Goniasteridae.

Clark and Rowe (1971) include *Asterodiscus* in the family Oreasteridae.

A. M. Clark (1974) replaced the preoccupied name *Asterodiscus* Gray (non *Asterodiscus* Ehrenberg, 1939 = Protozoa) with *Asterodiscides;* including it in the family Oreasteridae.

I think that the affinities between *Asterodiscides, Paulia, Pauliella* and *Amphiaster* have not been fully recognised, though Sladen had included the three known to him, from the literature, in one family. The uniqueness of this group of genera, in respect to recognised families, has obviously never been recognised.

The recognition of a new family was prompted by the examination of over a hundred specimens from widely separated Indo-Pacific localities. From these collections it became apparent that five species and one sub-species were also new to science. It seemed no longer possible to retain the genus *Asterodiscides* within either the Oreasteridae or Goniasteridae. Further investigation revealed the close relationships between this genus and *Paulia, Pauliella* and *Amphiaster.*

A large number of juvenile specimens, particularly from Western Australia, has allowed an assessment to be made of changes which occur with growth within certain members of the new family.

In this report, a standardised method of measurement has been adopted. The R and r measurements are taken from the centre of the disc to the distalmost vertical plane of each radius and interradius respectively. This seems to be more reliable, in determining shape, than attempting to measure to the terminal plate, either abactinally or actinally, especially since in some instances the ambulacral groove extends on to the abactinal surface.

The distalmost superomarginals are measured along their greatest horizontal (h.d.) and vertical (v.d.) diameters when viewed from the *side* of the arm.

The following abbreviations are used for Institutions which have loaned material for examination:

A.M. = The Australian Museum, Sydney, Australia.
B.M. = The British Museum (Natural History), London, England.
B.P.B.M. = Bernice P. Bishop Museum, Hawaii.
M.C.Z. = Museum of Comparative Zoology, Harvard, U.S.A.
N.M.W. = National Museum, Wellington, New Zealand.
U.S.N.M. = United States National Museum (Smithsonian Institution), Washington, D.C., U.S.A.
W.A.M. = Western Australian Museum, Perth, Australia.

Full locality data on the specimens examined during the course of this investigation is given in the list at the end of this paper.

SYSTEMATIC ACCOUNT

Family **Asterodiscididae** nov.

DIAGNOSIS: Pentagonal to stellate forms with a large disc. Juvenile form goniasterid-like. Abactinal skeleton reticulate, invested in a thick integument. Abactinal plates linked by internal radiating ossicles, which may develop into a complex supporting meshwork. Plates flat or slightly raised, each bearing an enlarged tubercle or a spine and a peripheral ring or rings of granules, or granules only. Granules and small tubercles occur on small plates which are supported in the investing integument which covers the open meshes. The skeletal meshes contain discrete groups of papulae, but this is not evident superficially. Superomarginal plates few, 3-5 on each side of the arm, with the distalmost sometimes enlarged. The superomarginals become separated from each other by intercalated intermarginal and abactinal plates as the animal increases in size. Inferomarginal plates, 8-18, likewise separated from each other by intermarginal and actinal plates. The two marginal series are separated from each other by the development of intermarginal plates. Papular areas may extend as far as the inferomarginal line but do not occur actinally. Adambulacral plates with a furrow series of spines (3-7) backed across the plate (at 90° to the furrow) by 1 (or 2) + 0 or 1 (rarely 2) + 0 or 1 well-developed, truncate spines. Pedicellariae foraminate, vertically elongate (forceps-shaped), sometimes absent. Interbrachial septum membranous. Tube-feet lacking spicules.

TYPE-GENUS: *Asterodiscides* A. M. Clark, 1974.

OTHER GENERA INCLUDED: *Paulia* Gray, 1840; *Amphiaster* Verrill, 1868.

REMARKS: This family has some characters in common with the families Oreasteridae and Goniasteridae: the reticulate skeleton invested in a thick integument, the groups of papulae (though not evident externally) (features of the Oreasteridae); the membranous interbrachial septum, the lack of spicules in the tube-feet (features of the Goniasteridae); the foraminate pedicellariae (feature of Goniasteridae but only few Oreasteridae); the absence of actinal papulae and the juvenile form (features shared with the Goniasteridae and Oreasteridae). This family is defined most clearly on the low number, form and arrangement of the marginal plates, the armament of the skeletal plates, the characteristic adambulacral armament and the distribution of the papulae.

KEY TO THE GENERA AND SPECIES OF THE FAMILY *Asterodiscididae*

1. Stellate or pentagonal forms; abactinal armament comprises tubercles <4 mm high; papulae extend to inferomarginal line; 3-4 superomarginal plates, distalmost larger than 2-3 proximal plates (except in *A. culcitulus* n. sp.); Indo-west Pacific: south-east Africa — Hawaii ..... *Asterodiscides* A. M. Clark, 1974 2
— Stellate forms; abactinal armament of large spines up to 6 mm high and 3 mm diameter at base; papulae restricted to abactinal surface above superomarginal line or few papulae extending to inferomarginal line; 4-5 superomarginal plates of similar size, distalmost *not* larger than proximal plates; Eastern-tropical Pacific: Galapagos — Lower California — Peru ..... *Paulia* Gray 1841 and *Amphiaster* Verrill, 1868 11
2. Pentagonal forms, R/r = 1.1-1.3 (rarely to 1.5, if so only 3 superomarginal plates present); 3-4 superomarginal plates; distalmost superomarginal either larger than proximal plates or of similar dimensions 3
— Stellate forms, R/r = 1.5-2.0; 4 superomarginal plates, (sometimes only enlarged distalmost superomarginal plate obvious); distalmost superomarginal always larger than proximal superomarginal plates 5

3. – Four superomarginal plates of similar size, distalmost *not* larger than 3 proximal plates, in specimens with R = 50 mm distalmost is separated from terminal plate by 1-2 small plates. West coast of Western Australia. ..... *A. culcitulus* sp. nov. (p.193).

— Three superomarginal plates, distalmost always adjacent to terminal plate and always much larger than 2 proximal superomarginal plates, in larger specimens only distalmost may be obvious but the animal is more or less pentagonal. .....*A. elegans* (Gray, 1847) (p.197). 4

4. Abactinal pedicellariae slender in vertical profile (forceps-like); actinal plates with up to seven subequal tubercles, one may be slightly more prominent than others; 4-5 furrow spines; R/r = 1.3-1.5; N. E. Australia — Philippines .....*A. elegans elegans* (Gray, 1847) (p.197).

— Abactinal pedicellariae flask-shaped in vertical profile (with bulbous base and tapering neck); actinal plates with one (rarely 2) large tubercles dominating plate; 3-4 furrow spines; R/r = 1.1-1.3; Southeast Africa, islands of western Indian Ocean, India, Ceylon. .... *A. elegans belli* subsp. nov. (p.199).

5. Distalmost superomarginal plates usually very large, flat or strongly convex, h.d. = v.d. or h.d. > v.d., when plate viewed from side of arm; two distalmost superomarginal plates at arm tip broadly contiguous abactinally above terminal plate; abactinal tubercles inverted cone-shaped or more or less cylindrical; furrow spines few in number (3-4); subambulacral spines in one or two series 6

— Distalmost superomarginal plates flat or only slightly convex, oval, h.d. < v.d. when plate viewed from side of arm; two distalmost superomarginals just in contact abactinally above terminal plate or just separated by it; abactinal tubercles rounded or apically pointed; furrow spines 5-7; subambulacral spines in two (very rarely in 3) series 8

6. Distalmost superomarginal plates strongly convex; 4-5 prominent inferomarginals under each distal superomarginal; abactinal tubercles more or less cylindrical; actinal tubercles subspherical; 3-4 furrow spines; one series of subambulacral spines; Southern and south-eastern Australia — New Zealand — Kermadec Islands. .... *A. truncatus* (Coleman, 1911) (p.200).

— Distalmost superomarginal plates flat, squarish; > 5 small inferomarginals under each superomarginal; abactinal tubercles inverted cone-shaped; actinal tubercles spatulate; 3 furrow spines; 2 series of subambulacral spines; Western Indian Ocean, Philippines — Japan. 7

7. Distalmost superomarginals with not more than h.d. = 1/5 R; abactinal tubercles rounded in cross-section, not forming mosaic-like pattern; Philippines — Japan. .....*A. helenotus* (Fisher, 1913) (p.202).

— Distalmost superomarginals with h.d. = 1/3 R; abactinal tubercles angular in cross-section, forming mosaic-like pattern when viewed from above; Western Indian Ocean. .....*A. tessellatus* sp. nov. (p.203).

8. Large forms with obese arms; abactinal tubercles very small, crowded, two sizes, larger tubercles (1.75 mm high) in three spaced, longitudinal rows along arm; only distalmost flat superomarginal plate distinguishable; actinal plates with one large conical tubercle (2.75 mm high) and peripheral ring of small, variously sized granules; actinal tubercles markedly larger than abactinal tubercles; R/r = 1.6; Western Australia (Shark Bay — Exmouth Gulf). .....*A. pinguiculus* sp. nov. (p.204).

— Arms not obese, narrowing to fairly acute tip; abactinal tubercles in 3 sizes, larger tubercles > 1.75 mm high; infero and superomarginal plates

all distinguishable; actinal plates with 4-10 subequal granules or tubercles; largest actinal tubercles not markedly larger than abactinal tubercles 9

9. Actinal plates with 1-2 central granules surrounded by 6-8 similar sized granules, *none* prominent; furrow spines usually 5; distalmost superomarginal more or less flat; proximal marginal plates with a cone-shaped process; no regular longitudinally alternating order of different sized tubercles; Western Indian Ocean (off Socotra) .... *A. lacrimulus* sp. nov. (p.206).

— Actinal plates with 4-10 unequal granules and tubercles, 1-3 more prominent; furrow spines 6-7; distalmost superomarginals slightly convex; other marginal plates without the cone-shaped processes; three sizes of abactinal tubercles in alternating, longitudinal rows along arms; N. E. Australia, Kermadec Islands, Hawaii 10

10. R/r = 1.5; inferomarginal plates predominantly bare; Hawaii. .... *A. tuberculosus* (Fisher, 1906) (p.207).

— R/r = 2.0; inferomarginal plates obscured beneath variously sized granules and tubercles; N. E. Australia, Kermadec Islands .... *A. grayi* sp. nov. (p.208).

11. Four superomarginal plates, all widely separated (3 in juvenile?); distalmost superomarginal plates on each side at arm tip spaced from terminal plate by large spiniferous plate and not contiguous abactinally above it; papulae restricted abactinally above superomarginal line; subambulacral spines in two series; Galapagos — Cocos Islands — Peru — Lower California..... *Paulia horrida* (Gray, 1840) (p.210).

— Four-five superomarginal plates, some plates in contact, others separated; distalmost superomarginals on each side at arm tip adjacent to and contiguous abactinally above the terminal plate; papulae extend to inferomarginal line, at least in specimens with R = > 38 mm; subambulacral spines in single series; Lower California .... *Amphiaster insignis* (Verrill, 1868) (p.212).

Genus **Asterodiscides** A. M. Clark, 1974

Asterodiscus Gray, 1847, p. 75; 1866, p. 5, pl. 12 figs 1-2; Perrier, 1875, p. 256; Viguier, 1878, p. 188, Sladen, 1889, pp. 343, 353; Ludwig 1899, p. 689; Fisher, 1906, pp. 1072, 1074; 1919, p. 354; H. L. Clark, 1946, p. 108; Spencer and Wright, 1966, p. U63; Clark and Rowe, 1971, p. 53. (non *Asterodiscus* Ehrenberg, 1839 = Protozoa)

Asterodiscides A. M. Clark, 1974, p. 435.

DIAGNOSIS: Body form pentagonal to stellate, R/r = 1.1-2.0; 3-4 superomarginal plates of which the distalmost is larger than the 2-3 proximal plates, bare and prominent (except in one species in which the distalmost superomarginal is as small as the 3 proximal plates); abactinal tubercles variously shaped, no higher than 4 mm; actinal graulation and tuberculation varied; intermarginal papulae abundant; furrow spines 3-7; subambulacral spines in 1 or 2, rarely 3, series.

TYPE-SPECIES: *Asterodiscus elegans* Gray, 1847.

OTHER SPECIES INCLUDED: *Asterodiscus tuberculosus* Fisher, 1906; *Asterodiscus truncatus* Coleman, 1911; *Asterodiscus helenotus* Fisher, 1913; *Asterodiscides culcitulus* sp. nov.; *A. elegans belli* subsp. nov.; *A. tessellatus* sp. nov.; *A. pinguiculus* sp. nov.; *A. lacrimulus* sp. nov.; *A. grayi* sp. nov.

REMARKS: Although the species now included in *Asterodiscides* exhibit a wide range of form, there does not appear to be sufficient justification for the establishment of named supraspecific groups.

The genus is separated from *Paulia* and *Amphiaster*, not only geographically but on the form and distribution of the marginal plates, the distribution of the papulae and the form of the abactinal armament.

Asterodiscides culcitulus n. sp.
Fig. 1 a-c

Asterodiscus sp. Marsh, 1972, p. 67-8

DIAGNOSIS: Pentagonal form at all stages of growth, R/r = 1.1-1.3, R up to 97 mm; 4 superomarginal plates of similar size, distalmost *not* larger than proximal plates, superomarginal plates become difficult to distinguish amongst the tuberculation with growth of the sea-star; up to 12 inferomarginal plates; abactinal tubercles subspherical, 3-4 sizes; actinal plates each with up to 7 subequal tubercles; furrow spines 5-7, subambulacral spines in 2 series, first series 2 spines per plate, second series 1 spine per plate; pedicellariae, when present, slender, forceps-like.

DESCRIPTION: Holotype W.A.M. No. 1063-74; Stn 104, 29° 29'S, 114° 12'E, W.S.W. Dongara, Western Australia, 108 m, 8.xii.70, H.M.A.S. 'Diamantina'.

The body is pentagonal, somewhat flattened, with R= 54 mm, r = 49 mm, R/r = 1.1 (fig. 1 a-c). There is a slight marginal indentation interradially, also, the abactinal interradial areas are sunken. Abactinal tubercles are of four sizes and are subspherical. The tubercles are largest (h.d. = 2.5 mm × v.d. = 2 mm) near the centre of the disc and are not arranged regularly along the arms. A ring of small granules is present around the base of the larger tubercles. Scattered between the largest tubercles are the tubercles of the other three sizes. The second and third sized tubercles also have granules at their bases, but the smallest tubercles, which are little larger than granules, do not. Interstitial granules are present but not dense. The madreporite is rounded, cushion-like and about 1/3r from the centre of the disc. Pedicellariae are very numerous, one usually associated with each of the tubercles. The bare marginal plates are obvious amongst the tuberculation. There are four superomarginal plates but the distalmost superomarginal is only slightly larger than the proximal three superomarginal plates (2.0 mm h.d. × 3.5 mm v.d.). The distalmost superomarginals are each surrounded by a ring of unequal granules, are not contiguous abactinally above the terminal plates and a pedicellaria is associated with each. The three other superomarginals (h.d. × v.d.: 2 mm × 2.5 mm; 2 mm × 2.2 mm; 2 mm × 2.7 mm) are spaced along the arm (fig. 1b). The second is 6 mm from the first, the third is 8.5 mm from the second and 8.5 mm from the distalmost. Each superomarginal is surrounded by a ring of small granules. There is a tubercle on the actinal edge of each proximal superomarginal, a pedicellaria on the abactinal edge and a second tubercle placed between; the rest of the plate is bare. There are nine inferomarginal plates, separated from the superomarginals proximally by five intermarginal plates. Only 2-3 inferomarginals underlie the distalmost superomarginal. The nine inferomarginals can be easily recognised from amongst the tuberculation. Each plate (the first five measure: h.d. × v.d. = mm; 2 × 3; 2 × 3; 2 × 3; 2 × 2.75; 2 × 2.5) comprises an actinally directed protuberance and has 1-2 tubercles on its abactinal edge. The plate is ringed by subequal granules and each plate has an associated pedicellaria (occasionally two). There is a sharp delimitation between the abactinal and actinal tuberculation at the level of the inferomarginal line.

The actinal plates bear up to seven subequal tubercles, of which one is usually very prominent and almost reaches the same size as the largest abactinal tubercles (fig. 1c). Unequal, sub-prismatic granules are present around the periphery of each plate. The plates are rather diamond-shaped. The tubercles are largest on the actinal plates adjacent to the adambulacral plates, where one tubercle becomes especially prominent on the distal plates. A pedicellaria is associated with most of the actinal plates.

The adambulacral plates (50) bear 6-7 furrow spines for the first 28-30 plates, 5 spines for the next five plates, thereafter 4 then 3 to the tip of the arm. The distalmost furrow spine is largest, proximalmost smallest, the second about 2/3 the size of the distal 3-6 spines. The subambulacral spines are in two series along the arm. The first series comprises two subequal spines on each plate. These are truncate, more or less aligned along the furrow though occasionally obliquely aligned, and extend for 15 plates after which the proximal spine becomes prismatic and granule-like and insignificant. The second series comprises a single, wide, flattened spine on each plate. This spine is small (almost insignificant) on each of the first seven plates, as often as not in the form of two subequal, pointed granules. After the seventh plate the spine is more prominent, but never attains the height of the larger first row spine. By the 25th plate the second series of subambulacral spines is again reduced, insignificant and granule-like. Each adambulacral plate also bears small angular granules around its periphery. No pedicellariae are present on the adambulacral plates.

The oral plates bear 9 furrow spines, 3-4 large actinal spines and 4 prismatic granules.

There are 11 Paratypes (PI-II); W.A.M. No. 1116-74; Stn 107, 30° 29'S, 114° 40'E, S. W. of Jurien Bay, Western Australia, 114 m, 9.xii.70, H.M.A.S. 'Diamantina'. These range in size from R = 57 mm (PI) - R = 34 mm (PII). They differ from the holotype in only very minor ways, including the presence of pedicellariae on the adambulacral plates and in the number of inferomarginal plates.

COLOUR: In life the smaller granules and integument are yellow brown abactinally, slightly darker in the centre of the disc and radially than interradially. The larger tubercles are cream to light yellow-brown. The very small specimens have the central tubercles, the radial areas and some superomarginal plates yellow-brown, the rest is cream (photograph and comments provided by Mrs L. M. Marsh, Western Australian Museum); preserved specimens are straw-coloured, with little indication of life colour.

OTHER MATERIAL EXAMINED: Besides the type-specimens, there are a further fifty-nine specimens collected from between Shark Bay and Mandurah off the west coast of Australia.

The smallest specimen measures R=6.5 mm, r=4.5 mm, R/r=1.3, and resembles a small *Tosia*. The largest specimen measures R = 97 mm, r = 75 mm, R/r = 1.3. The R/r ratio varies between 1.1-1.3, but is usually 1.2. The ratio is relatively constant with the difference between the minimum and maximum being only 18%. Considering the total number of specimens (71) examined, and the range of sizes (R = 6-97 mm), it would appear that the R/r ratio is a good species character.

With the exception of Fisher's (1906) description of two juvenile specimens of *Asterodiscus tuberculosus* from Hawaii, there has never been a large enough series of specimens on which to observe any growth changes. This collection, therefore, provides a unique opportunity to describe the changes which occur during the growth of an asterodiscidid. A representative series of specimens is discussed, from the smallest to the largest.

At R=6.5 mm (W.A.M. No. 1086-74) (fig. 1d), the central abactinal plate and ring of five primary radial plates and the five somewhat larger interradial plates are obvious. Between the radials and the abactinal central plate are 1 or 2 intercalary plates, and these preclude

contact between the central and the primary interradial plates. The madreporite is formed on the outer edge of one of the interradial plates. A row of four plates, smaller than the radial plate, extends as a carinal row to the comparatively large terminal plate of the arm. There are two rows of abactinal-lateral plates and 3-5 small plates in the remaining interradial triangle between two adjacent arms. The abactinal plates are circular, each with a peripheral ring of small granules and, centrally, 1-5 small, spherical tubercles. The largest abactinal plate has a diameter of 0.75 mm. The tip of the arm is turned up so that the triangular terminal plate is vertical. The marginal plates form a continuous border with four superomarginals and five inferomarginals. The distalmost superomarginal is small and wedged between the third superomarginal and the terminal plate. The superomarginals are bare, slightly convex and with a peripheral ring of small granules. The inferomarginals are similar. Between the superomarginal and inferomarginal series are 3-4 intermarginal tubercles. Actinal plates bear 3-12 granules, 1-3 of which are larger than the rest. There are 18 adambulacral plates, 5 or 6 furrow spines, reducing to 4-3 about half way along the furrow. The subambulacral spines are in a single row of two spines on each plate. Distal plates carry only one subambulacral spine. There are three granules on the outer edge of each adambulacral plate. The oral plate bears 6 furrow spines, 3 actinal spines and 3-5 granules.

At R = 10 mm (W.A.M. No. 1082-74) (fig. 1e), the rings of primary abactinal plates are not as obvious amongst the increased number of plates. Each has a central tubercle. Small tubercles are developed on small plates between the larger plates (but the diameter of the plates is still larger than the diameter of the tubercles). There is a carinal row and two lateral rows of plates and about ten plates are present in the interradial angle between two adjacent arms. Pedicellariae are present on one or two carinal plates. Successive marginal plates are spaced, with a channel between adjacent plates, except between the distalmost superomarginal and the terminal plate on the arm. The superomarginals are bare, with a peripheral ring of granules. There are six inferomarginal plates, each with 1 or 2 prominent tubercles on their abactinal edge. Intermarginal plates extend to between the 2-3 more or less vertically aligned pairs of marginals. The adambulacral plates bear 5-6 furrow spines, the proximalmost often the size of a granule. The subambulacral spines are in two series. The first series comprises two subequal spines on each plate, and the second series comprises a single spine, which develops from the middle of three granules, particularly on the distal half of the arm. The oral plate bears seven furrow spines.

In a specimen with R =12.0 mm(W.A.M. No. 1083-74), seven inferomarginal plates have developed and the intermarginal plates developed as far as the 3-4 vertical pair of marginal plates.

Surprisingly, a specimen with R = 12.5 mm (W.A.M. No. 1088-74) (fig. 1f), has only six inferomarginals. The distalmost superomarginal is as large as the third superomarginal and each superomarginal has an associated pedicellaria. There are a few actinal pedicellariae.

In a specimen with R = 14.5 mm (W.A.M. No. 1075-74) (fig. 1g), the diameter of the abactinal tubercles equals that of the abactinal plates. The regularity of the carinal and two abactinal-lateral rows of tubercles is just obvious. The distalmost superomarginal is larger than the other superomarginals. There are seven inferomarginals, some of which bear a pedicellaria. Intermarginal plates extend to between the 3-4 vertically aligned pair of marginals. There are 5-6 furrow spines, 4 distally, and the subambulacral spines are as in the holotype. There are no actinal pedicellariae on this specimen.

At R = 18 mm (W.A.M. No. 1070-74) intermarginal plates extend in a single line to the 3-4 supero- and inferomarginals but in the angles between vertically adjacent marginal plates two tubercled plates are present. The distalmost superomarginals are convex but the proximal superomarginals have a conical projection. There are 5-6 furrow spines for about half the length of the arm, thereafter only 4. The oral plates bear 9 furrow spines.

With increase to R= 23 mm (W.A.M. No. 1070-74) the abactinal regularity of tubercles is now less obvious. The distalmost superomarginal measures 2.5 mm v.d. × 1.5 mm h.d. and the proximal superomarginals are not very obvious amongst the general tuberculation. There are eight inferomarginals, with small plates occurring between adjacent inferomarginal plates. The intermarginal plates have increased to a definite double row, and, proximally, a triple row. Adambulacral armament as in the holotype.

At R = 30 mm (W.A.M. No. 1068-74) the distalmost superomarginal almost reaches its maximum size (3 mm v.d. × 2 mm h.d.). There are eight inferomarginal plates, each with a conical protruberance, a pedicellaria and some enlarged granules. The adambulacral plates bear 5-6 furrow spines for most of the length of the furrow and actinal pedicellariae are numerous.

At R = 38 mm (W.A.M. No. 1073-74) (fig. 1h), there is no observable order to the arrangement of the abactinal tubercles. There are nine inferomarginals with 1 or 2 plates between adjacent inferomarginal plates. The adambulacral plates bear 6-7 furrow spines for about half the length of the furrow. There are only a few actinal pedicellariae.

There is little, if any, variation occurring between R = 38 mm – R = 54 mm (holotype), except that the distalmost superomarginal becomes more obscured, especially in more bun-shaped (R/r = 1) specimens. There are, however, three specimens which greatly exceed the holotype in size.

In a specimen with R = 83 mm (W.A.M. No. 1069-74) the abactinal tubercles are closely packed and no order is apparent. The distalmost superomarginals are sub-terminal, being separated from the terminal plate by a small intercalary plate. The proximal superomarginals are only distinguishable after denuding. There are 10-12 inferomarginal plates, which are difficult to distinguish. There are 5-6 small plates separating adjacent inferomarginal plates. The two marginal series are separated by about 8 small plates proximally. The adambulacral plates bear 6 furrow spines along the greatest length of the furrow. The subambulacral armature is not unusual. The furrow recurves abactinally at the tip. The oral plates bear 10 furrow spines.

In a specimen with R = 93 mm (W.A.M. No. 1077-74) (fig. 1i-k), the abactinal tubercles are not as crowded. The distalmost superomarginals are not distinguishable at all and the proximal three superomarginals are difficult to distinguish even after denuding. There are 10-12 inferomarginals. The distal ones are difficult to find but the proximal six can be distinguished by the clusters of granules and tubercles on the plates. The adambulacral plates bear 7 furrow spines for the greatest part of the furrow, the first spine is often very small. Subambulacral spines not unusual, except the second series spine remains equal in length to the first series spine for the greatest part of the arm. The furrow tip is visible abactinally.

The largest specimen measures R = 97 mm (W.A.M. No. 1078-74). The abactinal tubercles are very crowded and no order is discernable. The superomarginals can only be distinguished after denuding. The distalmost superomarginal is separated from the terminal plate by two small plates. There are ten to twelve inferomarginal plates and the inferomarginal series is separated from the superomarginal series, at least proximally, by about twelve small plates. There are six furrow spines for most of the length of the arm and the furrow recurves abactinally at the tip. Pedicellariae are not common abactinally or actinally.

DISTRIBUTION: Between Shark Bay and Mandurah, on the west coast of Australia (25°-33°S Lat., 113°-115°E Long.), 90-180 m. (For details see Appendix 1.)

ETYMOLOGY: *culcitulus* (Lat.) = little cushion.

REMARKS: The characters that are exhibited by this species, particularly in respect to the form of the superomarginal plates, separate it easily from the other species considered in this paper.

Little is known of predation on starfish around the coasts of Australia so it is of interest to note that a large deep-water volutid (*Cottonia nodiplicata* (Cox)), collected off Mandurah, W.A., was seen to discharge asteroid plates, including tubercles of an 'undescribed *Asterodiscus*' in its faeces (Marsh, 1972), the asteroid being *Asterodiscides culcitulus*.

Asterodiscides elegans (Gray)

DIAGNOSIS: Pentagonal form, stellate in juvenile stage (subsp. *elegans*), R/r = 1.3-1.5, R up to 90 mm; only large distalmost, pear-shaped, flat — slightly convex superomarginal obvious in adults (R = > 50 mm), in juveniles 2 proximal, predominantly bare superomarginal plates are obvious (at least for subsp. *elegans*); up to 12 inferomarginal plates; abactinal tubercles subspherical — bluntly pointed, 3 sizes; actinal plates each with up to 7 tubercles (subsp. *elegans*) or with prominent single tubercle (subsp. *belli*); furrow spines 4-5 (subsp. *elegans*), 3-4 (subsp. *belli*), subambulacral spines in 2 series, first series 2 spines per plate, second series 1 spine per plate, occasionally in large specimens a third subambulacral spine is developed from a granule on the outer edge of the adambulacral plate; pedicellariae, when present, slender, forceps-like (subsp. *elegans*) or bulbous, flask-shaped (subsp. *belli*).

Asterodiscides elegans elegans (Gray)

Fig. 2 a-j

Asterodiscus elegans Gray, 1847, p. 75; 1866, p. 5, pl. 12, figs 1-2; Perrier, 1875, p. 256; Viguier, 1878, p. 188; Sladen, 1889, p. 353; Ludwig, 1899, p. 690; Fisher, 1919, p. 355, pl. 97, fig 2, pl. 101, fig 2; Spencer and Wright, 1966, U63; Clark and Rowe, 1971, pp. 34, 40, 53 (part).

non *Asterodiscus elegans*, Bell, 1907, p. 19 (part); Macnae and Kalk, 1969, p. 129; James, 1969, p. 52; Clark and Rowe, 1971, pp. 34, 40, 53, pl. 6 fig 4 (part).

non *Asterodiscides elegans*, A. M. Clark, 1974, p. 435.

DESCRIPTION: Holotype B.M. No. 45.3.5.353; no locality data, purchased Argent.

Body flattened abactinally, slightly concave actinally, with R = 36 mm, r = 24 mm, R/r = 1.5 (fig 2a-c). The arms are triangular from the base. Abactinal tubercles, of three sizes, are subspherical or bluntly pointed. The largest tubercles (h.d. = 1.25 mm × v.d. = 1.3 mm) are conical, surrounded at the base by a ring of small granules, and more or less form longitudinal lines along each arm. The two smaller-sized tubercles are rounded, scattered between the largest tubercles and do not possess a basal ring of small granules. The madreporite is rounded, cushion-shaped and is close to the centre of the disc and stands out white against the 'museum' colour of the abactinal surface. There are no abactinal pedicellariae.

The marginal plates are not very conspicuous, except the slightly convex distalmost superomarginals (h.d. = 3.5 mm × v.d. = 5.5 mm) (fig 2b). Each of these latter superomarginals is surrounded by a ring of small, rounded granules. There are two proximal superomarginal plates (h.d. × v.d. = mm: 1.75 × 2.2; 1.75 × 2.0) besides the distalmost one on each side of the arms. These are barely distinguishable amongst the tuberculation, but can be picked out because of the close grouping of 3-5 tubercles (of similar size to the smallest abactinal tubercles), these being surrounded by a ring of various sized, subquadrate granules. The second proximal superomarginal is 12 mm from the first and 10 mm from the distalmost superomarginal.

There are nine inferomarginal plates, each bearing a conical tubercle (of similar size to the largest abactinal tubercles). The remainder of the plate is covered with subquadrate granules of different sizes, up to fifty on the largest inferomarginal plate (fig 2b-c). The proximal inferomarginals are larger than the proximal superomarginals (the first five measure: h.d. × v.d. = mm; 2 × 3; 1.8 × 2.2; 1.8 × 1.9; 1.8 × 1.8). The inferomarginal series is separated from the superomarginal series, at least proximally, by about three rows of plates. There are no pedicellariae associated with the marginal plates. The actinal plates bear up to seven tubercles, of which one is more prominent and may reach the same size as the largest abactinal tubercles. No distinct arrangement of the actinal plates can be discerned because of the tubercle cover on the plates, except that the tubercles of the first actinal row adjacent to the adambulacral plates appear in a parallel line with the subambulacral spines (fig 2c). There are no actinal pedicellariae.

The adambulacral plates (c. 39) bear 5 furrow spines for at least the first 14 plates, 4, occasionally 5, to the 30th plate, diminishing to 3 then 2 thereafter to the 39th plate. The 3rd or 4th spine is largest, the proximalmost on each plate often very small, can easily be overlooked. Subambulacral spines are in two series. The first series is small, slender and overshadowed by the larger, blunt, distal spine of each pair. The proximal spine becomes smaller towards the arm tip and insignificant from about half way along the arm (c. 16th adambulacral plate). The second subambulacral series is similar to the first (fig 2c).

The oral plates bear 12 furrow spines and 3 actinal spines. Two of the actinal spines are equal in size and very prominent, the one in the apex of the plate is small and more slender.

OTHER MATERIAL EXAMINED: A specimen of similar size to that of the holotype was collected by the 'Albatross' in the Philippines (U.S.N.M. No. 40544) and fully described by Fisher (1919) (fig. 2d-e). The only minor differences that I can detect are that the largest abactinal tubercles are slightly larger than in the holotype; the regular number of 4 furrow spines; the very reduced proximal subambulacral spine in each pair; abundant abactinal and actinal pedicellariae.

The smallest specimen of *elegans* so far recorded is from 'N. China' (B.M. No. 47.6.18.4) (fig 2f-h). This specimen measures R = 24 mm, r = 16 mm, R/r = 1.5, and is figured by Gray (1866, pl. 12 fig. 2). The two proximal superomarginal plates are obvious because each is mainly bare but bears a tubercle of similar size to the largest abactinal tubercles on the upper part of the plate. The superomarginals are ringed by small granules. There is evidence of a few abactinal pedicellariae (the position of three was detected from the foramina in the plates) but there are no actinal pedicellariae. There are only eight inferomarginal plates and the inferomarginal series is separated from the superomarginal series (proximally at least) by two rows of plates.

In larger specimens of *elegans* the ratio R/r becomes lowered as the animal becomes larger. The specimen figured by Gray (1866, pl. 12 fig. 1) is larger than the holotype, measuring R = 43 mm, r = 32 mm, R/r = 1.35 (B.M. No. 43.3.10.9). The two proximal superomarginals are only distinct when denuded. There are 10 inferomarginal plates. Pedicellariae are numerous. (A.M. Clark, pers. comm.).

In two other specimens from 'China' (B.M. No. 49.1.31.4) and 'N. China' (B.M. No. 49.1.31.3) (fig. 2i), the proximal superomarginal plates are *not* distinguishable at all, even after denuding the arm. These specimens measure R = 62 mm, r = 47 mm, R/r = 1.3 and R = 64 mm, r = 49 mm, R/r = 1.3 respectively. There are ten to eleven inferomarginal plates, which can be distinguished by their size and tuberculation and without denuding the plates. The distalmost superomarginals measure h.d. = 5 mm × v.d. = 8 mm. A few abactinal and actinal pedicellariae are present.

The largest specimen that I have examined is from the Philippines and was collected by the 'Challenger' and identified by Sladen. It measures R = 90 mm, r = 67 mm, R/r = 1.3 (B.M. No. 1890.5.7.501) (fig. 2j). The abactinal tubercles are of three sizes and widely scattered. The distalmost superomarginals measure h.d. = 5.2 mm × v.d. = 9.25 mm. The proximal superomarginals are not distinguishable even after denuding the side of the arm. There are 12 inferomarginal plates which bear 1 or 2 large tubercles and from 8-10 subequal, wedge-shaped granules. Pedicellariae are present abactinally. The actinal plates bear 1-4 subequal tubercles, usually a slender pedicellaria and a peripheral ring of subequal, prismatic granules. The adambulacral plates bear 4, occasionally 5, furrow spines along most of the length of the arm. The subambulacral spines are large, truncate and in 2 or 3 series. The first and second series are of single spines, but occasionally the middle granule of three on the outer edge of each adambulacral plate is greatly enlarged, being almost equal in size to that of the inner spines and forming an irregular third series. Occasionally two of these granules are enlarged to spine-sized proportions. Distally this third series of spines is absent. A large lanceolate pedicellaria stands between the two first subambulacral spines on the adoral edge of each adambulacral plate. Unequal, small, prismatic granules occur along the ad- and abradial edges of the plates. There are eight furrow spines and five actinal spines on each oral plate.

Asterodiscides elegans belli subsp. nov.
Fig. 3a-d

Asterodiscus elegans, Bell, 1909, p. 19 (part); Macnae and Kalk, 1969, p. 129; James, 1969, p. 52; Clark and Rowe, 1971, p. 34, 40, 53, pl. 6, fig. 4, (part).

Asterodiscides elegans, A. M. Clark, 1974, p. 435.

DESCRIPTION: Five specimens from the Indian Ocean agree in almost all respects with the larger specimens of *elegans* described above. There are, however, three conspicuous differences. Firstly, the tuberculation of the actinal plates can be seen to be markedly different when the Indian Ocean forms and the China/Philippine forms are directly compared. In the Indian Ocean specimens each actinal plate is dominated by a single, large tubercle, rarely are 2 or 3 tubercles present, and when they are it is near the interradial margin of the animal (fig. 3d). The periphery of each plate bears prismatic granules. From examination of over seventy specimens of *A. culcitulus* sp. nov. (R = 6.5 mm to 97 mm) the actinal tuberculation appears to be constant throughout the size range, suggesting that the differences discussed here are real. Secondly, the furrow spine number is lower, 3-4 usually, rarely 5. Thirdly, the abactinal pedicellariae, when present, are distinctly flask-shaped, with a broad shoulder basally and a narrow neck. This is of course an unreliable character due to the lack of consistency in the occurrence of the pedicellariae. Nonetheless, the distinctive actinal tuberculation and the lower number of furrow spines seem sufficiently constant to recognise these features as important enough to warrant recognition of a subspecies *belli* subsp. nov. I nominate two specimens from the Amirante Islands as holotype (B.M. No. 1907.7.1.46) (fig. 3a-b) and paratype (B.M. No 1907.7.1.44) respectively. Three other specimens examined are from Madras, India (B.M. no. 1890.1.13.11-12(1); A.M.J9735 (1) two specimens) (fig. 3c-d) and Saya da Malha Bank, western Indian Ocean (B.M. No. 1907.7.1.45 (part); one specimen). Other specimens of *A. elegans* have been reported from East Africa (Macnae and Kalk, 1969; Clark, 1974) and Ceylon (James, 1969). I believe that these should be referred to *A. elegans belli*.

DISTRIBUTION: China (exact locality unknown, possibly South China Sea) — Philippines — North-east Australia (A. Birtles, pers. comm.) for *A. elegans elegans* (Gray). Indian Ocean, South Africa to Ceylon for *A. elegans belli* subsp. nov., 18-120m.

ETYMOLOGY: *belli* (subspecies) = named after F. J. Bell, who originally identified the material examined here.

REMARKS: *A. elegans elegans* and *A. elegans belli* appear to be most similar in form to *A. culcitulus*, differing in the number of superomarginal plates, in the relative size of the distalmost superomarginals to the proximal superomarginals and in the lower number of furrow spines. In larger specimens of each, when the proximal superomarginals are not easily distinguishable, the smaller size of the distalmost superomarginal, or its apparent absence, in *A. culcitulus* is sufficient to distinguish between the species. In juvenile specimens of each species the R/r ratio of *elegans elegans*, at least, is as high as 1.5, whereas that of *culcitulus* remains no more than 1.3, this latter species being more pentagonal at all stages of growth. However, the juvenile *elegans elegans* has only two proximal superomarginals and this will distinguish it from all other species in the family. The low R/r ratio alone will separate the two subspecies from all the other species described in this paper.

Asterodiscides truncatus (Coleman)
Fig. 3 e-g

Nectria ocellifera, H. L. Clark, 1909, p. 529 (non *Nectria ocellifera* Perrier, 1875)

Asterodiscus truncatus Coleman, 1911, p. 699, figs 123-125, pl. LXXXIII; H. L. Clark, 1916, p. 50; 1938, p. 101; 1946, p. 108; Powell, 1937, p. 78; Serventy, 1937, p. 81; Cotton and Godfrey, 1942, p. 199; Pope, 1951, p. 146, pl. frontispiece; Fell, 1958, p. 13; Shepherd, 1968, p. 737; Dartnall, 1968, p. 23.

DIAGNOSIS: Stellate form, R/r = 1.5-2.0, R up to 166 mm; 4 superomarginal plates, proximal 3 small, bare distalmost large, strongly convex, adjacent superomarginals at arm tip broadly contiguous abactinally above the terminal plate; 9-12 inferomarginal plates, the distal 4-5 underlying the distalmost superomarginal are unusually prominent; abactinal tubercles more or less cylindrical, 2 sizes; actinal plates each with a prominent tubercle surrounded by unequal granules; furrow spines 3-4 (rarely 5), subambulacral spines in a single series; pedicellariae slender, forceps-like.

DESCRIPTION: The description of the two syntypes given by Coleman is very detailed and little needs to be added here. The smallest specimen I have examined is from Tollgate Ids., N.S.W., Australia (A.M. No. J6910) and measures R = 44 mm. The large tubercles dominate, forming a carinal and two abactinal lateral rows. Scattered between are very small tubercles and granules. The three proximal superomarginal plates are obvious, each being convex and surrounded by a ring of small granules, these granules are notably absent from the base of the large tubercles. The distalmost superomarginals measure 5 mm h.d. × 4 mm v.d., are widely contiguous abactinally above the terminal plate and are strongly convex. There are nine inferomarginal plates, the first four bear a tubercle on the abactinal edge, the last four on the actinal edge. The latter four plates lie under the distalmost superomarginal. Each inferomarginal is surrounded by a ring of small granules. There are four rows of actinal plates, each plate with a prominent tubercle which is no more than ¼ the size of the largest abactinal tubercle. There are 5-6 very small tubercles in the distal interradial area between adjacent arms. The adambulacral plates bear three furrow spines and a single, large subambulacral spine, the outer three sides of the plate bearing small, subequal, prismatic granules. Small pedicellariae are present on the marginal plates, each of the plates of the first actinal row and on several of the remaining actinal plates.

The regularity of the arrangement of the abactinal tubercles becomes less as the animal increases in size. There can be, however, alternating rows of tubercles of two distinct sizes, but the concentration of scattered granules between the tubercles is variable. The position of the proximal superomarginals is less obvious in the larger specimens, but they can usually be detected because of the peripheral ring of small granules. The distalmost superomarginal can reach a size of h.d. = 10 mm.

The number of inferomarginal plates increases to 11 or 12 in specimens up to R = 166 mm. A feature which seems to stand out, but which has received little attention, is the large size of the 4 or 5 distal inferomarginals which lie under the distalmost superomarginal plate. This is a distinctive feature since in all other species known these inferomarginal plates are much smaller than the proximal ones.

The actinal armament is relatively constant, with one large, prominent tubercle on each plate, but the granulation covering the rest of the plate varies a little. The adambulacral armament is also relatively constant with 3 (rarely 4) furrow spines and a single subambulacral spine on each plate.

A specimen from Kermadec Islands (N.M.W. No. 1281), measuring R = 64 mm, r = 32 mm, R/r = 2.0, shows one or two interesting features. The proximal superomarginals are very difficult to distinguish but where they can be seen three can be counted. The distalmost superomarginals measure h.d. = 5.5 mm × v.d. = 4.5 mm and are *not* markedly convex. There are five furrow spines on the first 2-3 adambulacral plates, thereafter constantly four. All other features are in keeping with the species.

COLOUR: In life this species is variegated usually with pastel colours, mauve, orange and yellow appearing to predominate (Pope, 1951), though Shepherd (1968) records the colour as purple and red, and Powell (1937) describes the colours including chrome, vermilion and purple.

DISTRIBUTION: South and south-east coast of Australia, New Zealand to the Kermadec Islands, 14-792 m.

REMARKS: The form of the superomarginal plates, abactinal tuberculation and single series of subambulacral spines separates *truncatus* from all other species described in this paper.

Fisher (1919) considered *truncatus*, amongst the three species of *Asterodiscus* known at that time, to be the most closely related to his new species *A. helenotus*. However, the features indicated above and additionally the non spatulate form of the actinal tubercles and the low number of inferomarginal plates (4-5) under the distalmost superomarginals in *truncatus* easily separates the two species.

In some respects, *A. truncatus* shows affinities with *Amphiaster insignis* Verrill. The convexity and shape of the superomarginals, low furrow spine number and single subambulacral series are all similarities. However, I believe that the shape and extent of the abactinal and actinal tuberculation, the larger size of the distalmost superomarginal compared with the proximal three superomarginals and the very widely spaced marginal plates separate the two generically.

In his description of the species, Coleman (1911) clearly describes one specimen in detail (A.M. No. J1053) (fig. 3e-g) and compares a larger specimen (A.M. No. J2047), with the aid of figures of the latter specimen, with the smaller specimen. Both of these specimens are held in the Australian Museums collections. These two specimens are considered here as the only authentically described type-specimens (syntypes), material from other localities listed by Coleman merely indicating recognition by Coleman that those specimens also represent his newly described species but which have *not* served any part in the description of the species.

Asterodiscides helenotus (Fisher)
Figs 3h-i, 4a-b

Asterodiscus helenotus Fisher, 1913, p. 210; 1919, p. 357, pls 95 fig. 1, 1a; 96 figs 1-2.

A. hiroi Hayashi, 1938, p. 277, pl. 1 figs 5-7.

DIAGNOSIS: Stellate form, R/r = 1.6-2.0, R up to 98mm; 4 superomarginal plates, proximal three only obvious on juveniles, distalmost massive, flat, squarish, h.d. = no more than 1/5R, adjacent superomarginals at arm tip broadly contiguous abactinally above the terminal plate; 9 (juvenile) - 18 inferomarginal plates of which 8-9 underlie the distalmost superomarginal plate in adult specimens; abactinal tubercles inverted cone-shaped, rounded, not forming mosaic pattern when viewed from above; actinal plates each with single prominent spatulate tubercle; furrow spines 3-4, subambulacral spines in 2 series, one spine in each series per plate; pedicellariae, when present, slender, forceps-like.

DESCRIPTION: The descriptions of the holotype (U.S.N.M. No. 32633) (figs 3h-i, 4a) given by Fisher (1913; 1919) do not require repetition here. However, I have also had the opportunity of examining two juvenile specimens collected from the Sulu Archipelago, Philippines which I believe to be referable to *O. helenotus*, (W.A.M. Nos. 1080-74 and 1081-74).

The smaller specimen (1081-74) measures R = 14.4 mm, r = 8.6 mm, R/r = 1.67. The central-abactinal plate, ring of primary radial plates and somewhat larger interradial plates are obvious. As in the juveniles of *A. culcitulus* (p194) the interradials are precluded from contact with the central-abactinal plate because of two intercalary radial plates between each primary radial and the central plate. Each radial plate has a tubercle obscuring it and the interradials bear 1-2 small tubercles. There is a carinal row of seven tuberculate plates and three lateral rows, one or two plates are found in the interradial areas between adjacent arms. The plates bear a peripheral ring of small granules and a single, rounded tubercle. There are a few small tubercles scattered between the larger plates. The marginal plates are prominent. The distalmost superomarginal is larger than any of the others (2.2 mm h.d. × 2.0 mm v.d.). These superomarginals meet widely abactinally above the terminal plate. Each has a peripheral ring of small granules, there being a double row where the superomarginals are contiguous. There are three proximal superomarginals but two vertically placed tubercles occur between the second and third superomarginals and a line of three tubercles separate the third marginal from the distalmost superomarginal. In at least three cases the second superomarginal appears vertically divided, giving the impression of 5 plates. The tuberculate plates between the third and fourth superomarginals give the impression of being part of the series of plates, but the superomarginals are always distinctively larger and bare and with a peripheral ring of small granules. There may be 1-3 tubercles on the actinal edge of the superomarginal plates. There are 9 inferomarginal plates, four occurring under the distalmost superomarginal. The plates are conspicuously bare, with a peripheral ring of small granules and a conical tubercle on the abactinal edge. This tubercle becomes spiniform on the distal inferomarginal plates, especially on the plates underlying the distalmost superomarginal. A single line of intermarginal tuberculate plates is present, each plate being placed in the angle between the more or less vertically aligned marginals. These intermarginal plates extend to the fourth inferomarginal.

There are 5 rows of actinal plates each plate bearing 6-8 granules surrounding a rounded tubercle.

The adambulacral plates (35) each bear 3 or 4 furrow spines and two subambulacral spines. The inner subambulacral spine on each plate is large and longitudinally flattened, but tapering to the tip. The second spine is an enlarged granule, the middle one of three on the outer edge of the plate. There are usually 2-3 small granules additionally on the plate.

The oral plate bears seven furrow spines, three actinal spines and three or four prismatic granules. There are no pedicellariae on this specimen.

The second specimen (1080-74) measures R = 16.4 mm, r = 8 mm, R/r = 2 (fig. 4b). It has slightly narrower arms and the abactinal primary tubercles are more spaced, with secondary tubercles scattered between (roughly in alternating rows). The primary plates are not as obvious, but can be detected with careful examination. There are eleven inferomarginal plates. Apart from these small differences, due obviously to growth, the two juveniles are very similar.

I believe that the specimen from the vicinity of Seto, south western tip of Japan, which Hayashi (1938) described as *Asterodiscus hiroi,* is a small *helenotus.* The differences outlined by Hayashi do not seem tenable to me. The absence of pedicellariae is not unusual, the fewer abactinal tubercles and differences in the adambulacral armament can be explained by the difference in size between Hayashi's specimen and the holotype of *O. helenotus.* Hayashi's specimen was just over twice the size of the juvenile specimens described above.

DISTRIBUTION: Philippine Islands to the S.W. tip of Japan, 18-81 m.

REMARKS: *O. helenotus* is clearly most closely related to *O. tessellatus.* The differences are discussed on p.204 and can be seen in the dichotomous key on p.191.

Asterodiscides tessellatus sp. nov.
Fig. 4c-g

Asterodiscus elegans, Bell, 1909, p. 19 (part), (non *A. elegans* Gray, 1841).

Asterodiscus helenotus, Clark and Rowe, 1971, pp. 34, 40 (part); Grzimek, 1974, p/pl. 379, (non *A. helenotus* Fisher, 1913).

DIAGNOSIS: Stellate form, R/r = 2.2-2.5, R up to 47 mm; 4 superomarginal plates, proximal three small, obscured unless arm denuded, distalmost massive, flat, squarish, h.d. = 1/3R, adjacent superomarginals at arm tip broadly contiguous abactinally above the terminal plate; 14-16 inferomarginal plates, with 8-9 under distalmost superomarginal; abactinal tubercles inverted cone-shaped, flat-topped, polygonal in cross-section, forming a mosaic pattern when viewed from above; actinal plates each with single spatulate tubercle; furrow spines 3, subambulacral spines in 2 series, one spine per plate in each series; pedicellariae slender, forceps-like, only observed actinally.

DESCRIPTION: Holotype B.M. No. 1907.7.1.45 (part); Saya da Malha, western Indian Ocean, 99 m., Stanley Gardiner Expedition.

The body is stellate, R = 40-46.6 mm, r = 18.5 mm, R/r = 2.2-2.5 (fig. 4c-e). The arms have more or less parallel sides. Abactinal tubercles are in three sizes and are not regularly arranged. All the tubercles are flat-topped, polygonal in cross-section and inversely conical. The arrangement of the tubercles is such that they form a mosaic when viewed from above. The base of each tubercle is surrounded by a ring of small granules and no other granules are present abactinally. The largest tubercles have an apical diameter of c. 2 mm and stand about 1 mm high. The madreporite is small and almost hidden under adjacent apically expanded tubercles. There are no abactinal pedicellariae.

The superomarginal plates are not conspicuous unless denuded, except for the distalmost one (fig. 4d). There are four superomarginal plates, the proximal three are small, 1.75 mm h.d. × 1.75 mm v.d. but the distalmost superomarginal is massive, 15-16 mm h.d. × 11-11.5 mm v.d., flattened and widely contiguous abactinally above the terminal plate. In

the depression between the abactinally joined plates are six rows of small granules. The superomarginal plates form a lip with their outer edge, under which are two rows of small granules (fig. 4e). There are three plates between the third superomarginal and distalmost superomarginal plates. There are 14-16 inferomarginal plates, of which about 9 occur under the distalmost superomarginal. (The first five inferomarginal plates each have h.d. × v.d. = 1.75 mm × 1.75 mm). The superomarginal and inferomarginal series are separated by two rows of plates.

Actinal plates in 3-4 rows. Each plate bears a single, large spatulate tubercle and a peripheral ring of small, wedge-like, unequal granules (fig. 4e). One or two plates carry a slender pedicellaria.

Adambulacral plates (c.54) extend on to the abactinal surface at the tip of the arm. Each plate bears 3 furrow spines, the first of which is shorter than the other two which are equal in length. There are two subambulacral spines, which form two rows along the length of the arm. The first subambulacral spine on each plate is elongate, longitudinally flattened and standing at an oblique angle to the furrow. The second, outer, spine stands just forward obliquely from the first spine, is about $\frac{1}{2}$-$\frac{1}{3}$ length of the first spine, longitudinally flattened but with the flat edge parallel to the furrow (fig. 4e). The remaining periphery of the plate bears small, wedge-shaped granules. No pedicellariae occur on the adambulacral plates.

The oral plate bears 7 furrow spines and 2 actinal spines.

Paratype B.M. No. 1907.7.1.45 (part); locality same as holotype.

The paratype (fig. 4f-g) differs in only a few minor details from the holotype: R = 33-35 mm, r = 17.5 mm, R/r = c.2. The distalmost superomarginals measure 10.5 mm h.d. × 8.5 mm v.d. There are only 3 rows of actinal plates and about 44 adambulacral plates.

COLOUR: The holotype is preserved in alcohol and is uniformly cream. The colour of the paratype in alcohol is uniformly light coffee brown.

DISTRIBUTION: Saya da Malha (Western Indian Ocean), to 99 m.

ETYMOLOGY: *tessellatus* (Lat.) = referring to the mosaic pattern of abactinal plates.

REMARKS: *A. tessellatus* is closely related to *A. helenotus*. Bell (1909), however, identified these specimens as *Asterodiscus elegans*. Clark (in Clark and Rowe, 1971) re-identified the two specimens as *A. helenotus* Fisher. However, it seems to me that the specimens represent a new species, differing from *helenotus* principally in the shape and arrangement of the abactinal tubercles, the massive distalmost superomarginal (equalling 1/3R) and in the general size. I do not believe that the features used to separate the species *tessellatus* from *helenotus* can be attributed to size difference, particularly after having examined two small, juvenile specimens of *helenotus*.

A coloured photograph of *A. tessellatus* (labelled *A. helenotus*) is included in Grzimek's (1974) *Animal Life Encyclopaedia*, Volume 3, page/plate 379. It shows the animal to be a salmon-pink colour in life. The locality of the specimen photographed is unknown (Dr H. Fechter, pers. comm.).

Asterodiscides pinguiculus sp. nov.
Fig. 4h-j

DIAGNOSIS: Stellate form, R/r = 1.6, R up to 58.5 mm; only marginal plates discernable are the flat, pear-shaped distalmost superomarginals and the underlying 4-6 distal inferomarginals; between the proximalmost inferomarginal and the proximal curved edge

of the superomarginal above is a triangle of about 15 tuberculate plates, noticeably larger than the adjacent plates of the side of the arm; abactinal tubercles small, closely packed, 2 sizes; actinal plates each with 1-2 large, central tubercles, markedly larger than abactinal tubercles; furrow spines 3-5, subambulacral spines in 2 series, one spine in each series per plate, rarely a third spine develops from granule on outer edge of adambulacral plate; pedicellariae sometimes present.

DESCRIPTION: Holotype W.A.M. No. 1079-74; N.E. of Bernier Is., Shark Bay, Western Australia, 23-27 m., 25.vi.71. D. Heald.

The holotype is stellate, measuring R = 92.5 mm, r = c.58.5 mm R/r = c.1.6, (fig. 4h-j). The arms are obese, with well rounded tips, Br = 66 mm. The adambulacral furrow recurves abactinally at the arm tip so as to be visible when the animal is viewed from above. Abactinal tubercles are closely packed and of only two distinct sizes. The largest tubercles are sharply conical (h.d. = 1.75 mm × v.d. = 1.75 mm) and are surrounded at the base by a ring of small granules. Three rows of these tubercles extend along about 1/3R (6-7 per row, well spaced). The closely packed smaller tubercles are circular when viewed from above, but mushroom-shaped when viewed from the side. Interstitial granules are scattered between the tubercles. The madreporite is oval (6 mm × 4 mm).

With the exception of 4-6 distal inferomarginal plates under the prominent distalmost superomarginal plate, the actual number of superomarginal and inferomarginal plates cannot be stated since none of the other marginal plates are discernable, even after denuding the side of the arm (fig. 4i). The distalmost superomarginals are pear-shaped, flat (h.d. = 7 mm × v.d. = 12 mm) and each is surrounded by a peripheral ring of small granules. There are 4-6 small inferomarginal plates below each of the distalmost superomarginal plates, but between the proximalmost of these inferomarginal plates and the proximal curved edge of the adjacent superomarginal is a triangle of about 15 plates which are noticeably larger than the adjacent plates of the sides of the arms (fig. 4i). Each of these larger plates bears a large conical tubercle (c. 1.75 mm × 1.75 mm). There is a sharp delimitation between the end of the smaller tubercles of the abactinal surface and the very much larger actinal tubercles at the actinal / abactinal edge of the arms and disc. This is also marked by an abrupt colour change.

The actinal plates bear usually one large conical tubercle (measuring up to h.d. = 2.75 mm × v.d. = 2.75 mm) and a peripheral ring of variously sized, subquadrate granules. Adjacent to the furrow the plates usually bear two large tubercles, (fig. 4j).

The adambulacral plates (c. 50) bear 3-5, usually 5, furrow spines for the first 35 plates, thereafter 4 or 3. The proximal spine is smaller than the others which are almost equal in size. There are two series of subambulacral spines. The inner one on each plate is flattened and the outer one tapering. The outer edge of each adambulacral plate usually has three large granules of which, occasionally, the central granule is enlarged to a spine of equal size to the other two subambulacral spines on the plate. Prismatic granules occur on the proximal and distal edges of the plates. Occasionally two subequal subambulacral spines occur on each plate in the first series of spines (fig. 4j).

The oral plates bear 10 furrow spines and 5-6 large actinal spines.

No pedicellariae occur on the holotype.

A second specimen, collected from Exmouth Gulf, measures R = 61, r = 41, R/r = 1.5, (W.A.M. 361-76). It differs little from the holotype except that it has numerous pedicellariae.

COLOUR: The colour in life is a deep, uniform maroon abactinally, slightly lighter actinally (photograph provided by Mrs. L. M. Marsh, Western Australian Museum); the dried specimen is similarly coloured.

DISTRIBUTION: Shark Bay to Exmouth Gulf, Western Australia, 7-27 m.

ETYMOLOGY: *pinguiculus* (Lat.) = fattish, referring to the general shape of the animal.

REMARKS: The size and shape of *pinguiculus*, the small, crowded abactinal tubercles, the apparent lack of proximal superomarginal plates and the marked distinction between the size of the abactinal and the larger actinal tubercles sets this species apart from any of the other known species in this genus. The most closely related species appear to be *A. lacrimulus*, *A. grayi* n. spp. and *A. tuberculosus* (Fisher).

Asterodiscides lacrimulus sp. nov.
Fig. 5a-c

DIAGNOSIS: Stellate form, R/r = 1.5, R up to 68 mm; 4 bare superomarginal plates, proximal 3 produced into abactinally directed cone housing slender pedicellariae in crescentic depression, distalmost superomarginal largest, flat, tear-shaped; 11-12 bare inferomarginal plates, proximal 6-8 with actinally directed cone; abactinal tubercles fine, acutely conical, 3 sizes; actinal plates each with 8-12 subequal granules, none are tuberculiform; furrow spines 5, subambulacral spines in 2 series, first series 2 spines per plate, second series 1 spine per plate; pedicellariae slender, forceps-like.

DESCRIPTION: Holotype U.S.N.M. No. E15833; Stn 444, Cruise 9, 09° 36′ N, 51° 01′ E (off Socotra, N.W. Indian Ocean), 78-82 m, 16.xii.64, 'Anton Bruun' (I.I.O.E.).

The animal is distinctly stellate, measuring R = 57.5 mm, r = 37.5 mm, R/r = 1.53, (fig. 5a-c). The arms are triangular, with a fairly acute tip. The adambulacral furrow recurves abactinally at the arm tip so as to be just visible when the animal is viewed from above. The abactinal tubercles are acutely conical and of three distinct sizes. The largest are spaced in a carinal and two lateral rows along the length of the arms and measure h.d. = 1.7 mm × v.d. = 2.4 mm. A ring of small granules occurs around the base of each of these and the two lesser sized tubercles. These latter tubercles are scattered, without regular order, between the larger tubercles. Interstitial granules are scattered between the tubercles. A slender pedicellaria is associated with many of the tubercles.

The marginal plates are not immediately obvious amongst the tuberculation, except the distalmost superomarginals (h.d. = 3.3 mm × v.d. = 6.0 mm) which are narrow, tear-shaped (fig. 5a-b). The pair at each arm tip are just contiguous above the terminal plate. Each superomarginal plate is surrounded by a peripheral ring of small granules. There are three proximal superomarginal plates, each usually predominantly bare and with the surface produced into an abactinally directed cone. On the abactinal edge, seated in a crescentic depression, is a slender pedicellaria. On the actinal edge are two conical tubercles of similar size to the larger abactinal tubercles. Each plate has a peripheral ring of small granules. The second superomarginal is 4 mm from the first and 7 mm from the third, the third superomarginal is 12 mm from the distalmost plate. Each of the proximal superomarginal plates measures h.d. = 2.2 mm × v.d. = 2.2 mm. There are 11 or 12 inferomarginal plates, of which 4-5 lie under the distalmost superomarginal. The shape of the plates is similar to that of the proximal superomarginals but with the cone directed actinally. Each of the first five inferomarginal plates measure h.d. × v.d. = mm: 2.2 × 2.75. The marginal series are separated, at least proximally, by about three rows of plates (fig. 5b).

The actinal plates bear 1 or 2 central granules surrounded by 8-10 subequal, subquadrate granules. There are *no* prominent granules on the plates except towards the inferomarginal line, where one granule becomes larger and rounded and may be

considered as a tubercle. The actinal plates are seen to be in distinct lines because of the more even size and distribution of the granules on each of the plates (fig. 5c). Most of the plates bear a pedicellaria.

The adambulacral plates (60) bear five furrow spines for at least the first 30 plates, thereafter 4 then 3 distally. The first spine is generally about one half the length of the second, which is slightly shorter than the other three spines. The subambulacral spines are in two series. The first series comprises two obliquely aligned spines on each of the first 30 plates, after which the proximalmost of the two spines becomes small and insignificant. The second series comprises a single spine, behind the first pair on each plate, which is broadly flattened, being equal in width to the inner pair of spines. Distally this spine becomes spiniform and tapering (fig. 5c). The proximal, distal and outer edges of the adambulacral plates bear prismatic granules.

The oral plates bear 9 furrow spines and 5 actinal spines.

Paratype A.M. No. J9792; Stn. 463, Cruise 9, 11°24'N, 51°35'E (off Socotra, N.W. Indian Ocean), 75-175 m, 17.xii. 64, 'Anton Bruun' (I.I.O.E.).

The paratype differs in only a few minor details from the holotype: R = 68 mm, r = 46 mm, R/r = 1.49. The largest abactinal tubercles measure h.d. = 1.7 mm × v.d. = 3.0 mm. The distalmost superomarginals measure h.d. = 3.0 mm × v.d. = 6.6 mm. There are about 65 adambulacral plates. The specimen is dried and of similar colour to the holotype.

COLOUR: The holotype is dried and is a dirty brown above, lighter actinally. The colour in life is not recorded.

DISTRIBUTION: Off Socotra, Indian Ocean, 75-175 m.

ETYMOLOGY: *lacrimulus* (Lat.) = little tear, referring to the shape of the distalmost superomarginal plates.

REMARKS: This species appears to be most closely allied to *A. tuberculosus* (Fisher), and *A. grayi* sp. nov. It differs from both in the finer abactinal tuberculation, the arrangement of the granules on the actinal plates, the fewer furrow spines, the distinctive shape of the proximal superomarginal and inferomarginal plates and the flatness of the distalmost superomarginal plate. *A. lacrimulus* is also distinguished from *grayi* by its lower R/r ratio

Asterodiscides tuberculosus (Fisher)
Fig. 5d

Asterodiscus tuberculosus Fisher, 1906, p. 1075, pl. xxvi figs 2, 2a; pl. xxviii fig. 3; pl. xxxii figs 3, 4; pl. xxxiii fig. 2; pl. xxxiv figs 1-2.

DIAGNOSIS: Stellate form, R/r = 1.5, R up to 69 mm; 4 bare superomarginal plates, distalmost superomarginal largest, oval, slightly convex, adjacent superomarginals at arm tip just contiguous abactinally above the terminal plate; 10-11 inferomarginal plates predominantly bare; abactinal tubercles bluntly pointed — subspherical, 3 sizes; actinal plates with up to 2 tubercles; furrow spines 5-6, subambulacral spines in 2 series, first series 2 spines per plate, second series 1 spine per plate; pedicellariae slender, forceps-like.

DESCRIPTION: There is nothing to add to Fisher's description of the holotype (fig. 5d), and two juvenile specimens. I have re-examined the holotype (U.S.N.M. No. 21172) and a third juvenile specimen collected from off Rabbit Island, Oahu in 396 m of water (B.P.B.M. No.

W1148). This latter specimen is smaller than Fisher's juveniles, measuring only R = 7.5 mm, r = 5 mm, R/r = 1.5, but corresponds very closely to the description given by Fisher for his specimens measuring R = 10 mm, r = 6.5 mm, R/r = 1.54.

DISTRIBUTION: Off Hawaiian Islands, 59-396 m.

REMARKS: *A tuberculosus* is most closely related to *A. grayi* sp. nov. and *A. lacrimulus*. The differences are outlined under those two species and are evident from the dichotomous key (p.192).

Asterodiscides grayi sp. nov.
Fig. 5e-f

DIAGNOSIS: Stellate form, R/r = 2.0, R up to 75 mm; 4 bare superomarginal plates, distalmost superomarginal largest, oval, slightly convex, adjacent superomarginals at arm tip just contiguous abactinally above the terminal plate; 10 inferomarginal plates obscured under granules; abactinal tubercles sharply pointed — subspherical, 3 sizes; actinal plates with up to 12 tubercles; furrow spines 5-7, subambulacral spines in 2 series, first series 2 spines per plate, second series 1 spine per plate; pedicellariae slender, forceps-shaped.

DESCRIPTION: Holotype A.M. No. J8719; Stn 2, 27°27'22"S, 153°39'E, Moreton Bay, Queensland, 75 m, 29.iii.69, H.M.A.S. 'Kimbla' (Dr. Ponder).

The specimen is distinctly stellate but contorted, with one mutilated arm, but measures R = c.65 mm, r = c.30 mm, R/r = c.2.2 (fig. 5e-f). The arms are relatively slender, tapering to a fairly acute tip. The abactinal tubercles are rounded to sharply conical, and in three distinct sizes. The largest (h.d. = 2.35 mm × v.d. = 2.75 mm) are acutely conical and form a carinal and two lateral rows along the length of the arms, a third lateral row being more or less evident. Each tubercle has a ring of small granules around its base. The tubercles are largest on the disc, diminishing in size towards the arm tip. Between these tubercles are the closely packed rounded tubercles of the two lesser sizes. The three largest sizes of tubercles tend to form alternating longitudinal rows along the arms. Small granules surround the base of the smaller tubercles. Interstitial granules occur between the tubercles. Pedicellariae are common abactinally, one being closely associated with most of the two largest-sized tubercles.

The marginal plates are not conspicuous amongst the tuberculation excepting the distalmost superomarginal plates which measure h.d. = 4.75 mm × v.d. = 6.75 mm and are bare and slightly convex. There are three proximal superomarginal plates. The innermost is close to the interradial line, the second is about 5 mm from it and the third is about 8 mm from the second and 35 mm from the distalmost plate. The three proximal plates vary in shape from sub-circular to distinctly vertically elongate. Each is strongly convex, bare and surrounded by a ring of small, subquadrate granules, these being at least twice the size of those around the base of the tubercles (fig. 5f). A pedicellaria is associated with each of the proximal superomarginals.

There are ten inferomarginal plates which are of similar size to the proximal superomarginals. Each is surmounted by about twelve granules of which one, two or three are conical to rounded and distinctly larger and tuberculiform. A pedicellaria is associated with most of the inferomarginal plates (fig. 5f). The actinal plates bear up to seven tubercles of various sizes, surrounded by a peripheral ring of small granules. Usually 1-4 of the tubercles are larger than the others and are quite prominent. The actinal plates do not appear to be arranged in any apparent order, with the exception of the row adjacent to the adambulacral plates. This is marked by the prominence of two large conical tubercles on proximal plates, and one on distal plates. A pedicellaria is associated with most of the actinal plates.

The adambulacral plates bear 6 or 7 furrow spines on the first 22-24 plates, reducing to five and distally four spines. The distal three spines are of about the same size but the three or four proximal spines decrease in size adorally so that the innermost spine is only about one half the length of the outermost spine. The subambulacral spines form two series. The inner series comprises two subequal spines on each plate which are aligned parallel with the furrow. The spines are stout, blunt and proximally the adoral spine is smaller than its companion. However, after about the tenth to twelfth plate the aboral of the two spines is the smaller, this spine becoming minute near the tip of the arm. The remaining adoral spine becomes slender and spiniform. The outer series of subambulacral spines comprises a single spine on each plate. This spine is flattened, equal in length to the two inner spines on the plate and equal in width to the inner pair of spines. This spine similarly becomes slender and spiniform distally. Small, wedge-shaped granules occur on the proximal, distal and outer edges of the adambulacral plates.

The oral plates bear twelve furrow spines and seven to eight actinal spines.

A specimen from the Kermadec Islands (N.M.W. No. Ech1280), measuring R = 75 mm, r = 37 mm, R/r = 2.0, differs from the holotype in the form of the armament of the skeletal plates. The abactinal tubercles are subspherical with only those nearest the tip of the arm showing any slightly conical shape. The actinal plates bear usually only five tubercles, of which one is much larger, though they are all more or less equal in height. Each of the plates adjacent to the adambulacral plates bears 4-5 tubercles of which one practically dominates the whole plate. This row of large tubercles stands out clearly. The inferomarginal plates are also each dominated by usually one, rarely two, subspherical tubercles, the rest of the plates bearing 5-8 small, unequal granules. Until more comparative material is available, I do not think that these features alone are of sufficient importance to justify the recognition of this specimen as a species which is distinct from *A. grayi*. Two specimens collected from Norfolk Island (New Zealand Oceanographic Institute collection) intergrade in the form of armament between the two specimens described above.

COLOUR: The holotype of *A. grayi* is preserved in alcohol and is uniformly off whitish, the colour in life is not recorded. The other specimens of *A. grayi* are dried and uniformly muddy brownish, the colour in life is not recorded.

DISTRIBUTION: Moreton Bay, N.E. Australia, to Norfolk Island and the Kermadec Islands, 70 to 75 m.

ETYMOLOGY: *grayi* = named after J. E. Gray who described many asteroid taxa including the type species of *Asterodiscides*.

REMARKS: *A. grayi* appears to be most closely allied to *A. lacrimulus* and *A. tuberculosus*. It differs from *lacrimulus* in the higher number of furrow spines, course abactinal tuberculation, the more slender arms and in the actinal plate armament. It differs additionally from *tuberculosus* in the tuberculation of the inferomarginal plates. Differences with the other species included in this genus are evident from the dichotomous key (p.192).

Genus **Paulia** Gray, 1841

Paulia Gray, 1840, p. 278; Sladen, 1889, p. 343; Ludwig, 1899, p. 690; Döderlein, 1935, p. 73; 1936, pp. 311, 318; Spencer and Wright, 1966, p. U63.

Goniodiscus (part) Müller and Troschel, 1842, p. 57.

Nidorellia, Perrier, 1875, p. 251 (part) (non *Nidorellia* Gray).

?Pauliella Ludwig, 1905, p. 151.

DIAGNOSIS: Body form stellate, R/r = c.2.0; all 4 (? 3 in juvenile) superomarginal plates bare and of similar size; distalmost superomarginal plates separated from the terminal plate by a large spiniferous plate; abactinal plates with large, acute spines, h.d. = 3 mm (at base) × v.d. up to 6 mm; actinal plates with 1-2 tubercles surrounded at the base by granules; intermarginal papulae absent; furrow spines 4-5; subambulacral spines in 2 series.

TYPE-SPECIES *P. horrida* Gray, 1840 (by monotypy).

REMARKS: The skeletal plate armament of this genus is similar to *Amphiaster*, but the arrangement of the distalmost superomarginal plates, the distribution of the papulae and the triserial as opposed to biserial adambulacral armament will distinguish *Paulia* from *Amphiaster*. Differences in skeletal armature, additionally will separate *Paulia* from *Asterodiscides*.

Paulia horrida Gray
Fig. 5g-i

P. horrida Gray, 1840, p. 278; 1866, p. 8; Ludwig, 1899, p. 690; H. L. Clark, 1902, p. 523; 1910, p. 333; Döderlein, 1936, p. 318; Spencer and Wright, 1966, p. U63.

Nidorellia horrida, Perrier, 1875, p. 254.

P. horrida var. *galapagensis* Ludwig, 1905, p. 143, pls XIII figs 63-64; XXIV figs 135-137, XXV figs 142-143.

?Pauliella aenigma Ludwig, 1905, p. 151, pls XII figs 58-60, XXIII fig. 133, XXIV fig. 138, XXV fig. 144, XXVI fig. 145.

DIAGNOSIS: As for genus.

DESCRIPTION: The species was described very summarily by Gray (1840). Perrier (1875) redescribed Gray's type-specimen. Ludwig (1905) gave a detailed description of both his variety *galapagensis* and of *Pauliella aenigma*.

The specimen at hand (A.M. No. J9654) (fig. 5g-i) is from Tagus Cove, Albemarle Island. Galapagos (Velero stn 330-35). The specimen measures R = 60 mm, r = 31 mm, R/r = c.2.0. The abactinal spines are in a carinal and two lateral rows, with 4-5 small spines in the interradial angle between adjacent arms. Around the base of each spine are one or two rings of small granules. Between the spined plates are smaller plates hidden under a covering of granules (fig. 5g). There are four superomarginal plates, which are tumid, bare and with two peripheral rings of granules. The plates are of similar size and the distalmost is separated from the terminal plate by a large spinebearing plate. There are eight inferomarginal plates, of which the distal 4-5 bear a spiniform tubercle. The marginal series are separated by two rows of spine bearing plates, at least proximally, amongst which are scattered smaller plates. Adjacent superomarginal plates and adjacent inferomarginal plates are likewise separated (fig. 5h). The actinal plates form 3-4 chevrons in the actinal intermediate areas. Each plate bears one to two stout apically rounded tubercles and two rings of granules. The adambulacral plates bear four furrow spines and two subambulacral spines, the remaining periphery of the plate bearing small granules. Occasionally the first subambulacral spine is accompanied by a small, aborally placed spine, or else a large, foraminate pedicellaria of similar size to the subambulacral spine (fig. 5i). Small foraminate pedicellariae occur on the actinal and marginal plates. The

papulae appear isolated, but are, in fact, in small groups of about 6-8. They are abactinal only and do not extend beyond the superomarginal line.

DISTRIBUTION: Punta Santa Elena, Ecuador, Peru, Galapagos Islands, Cocos Islands, Lower California.

REMARKS: Ludwig (1905) considered that the specimens from Galapagos Islands, which are smaller than the type-specimen from Ecuador, represent a variety of *P. horrida*. In lacking comparative material to verify Ludwig's proposal, I follow Döderlein (1936) in not recognising the status of *galapagensis*.

Ludwig (1905) painstakingly described *Pauliella aenigma* from two juvenile specimens from Cocos Islands (tropical eastern Pacific). He considered that they might represent juvenile *Paulia*, of which nothing at present is known. *P. aenigma* has not been reported since it was first described and the species has subsequently been considered a synonym of *P. horrida* (Döderlein, 1936). However, *Pauliella* has only *three* superomarginal plates (at R = 13.5 mm-16.5 mm) whereas *P. horrida* has four superomarginal plates. Examination of three specimens of *Amphiaster insignis* has shown an increase from four superomarginals (at R = 27.5 mm) to five superomarginals (at R = 38.5 mm and above). A study of a large series of juvenile to adult forms of *Asterodiscides culcitulus*, as well as several juveniles of one or two other species of that genus, indicates that the number of superomarginals does *not* increase above the number seen in the juvenile specimens (at least from R =6.5 mm). Also, the R/r ratio appears to remain pretty constant from juvenile to adult. The ratio in the young *P. aenigma* is 1.3-1.4, whereas in the adult *P. horrida* it is about 2.0, an increase of about 50%.

It seems, therefore, that until a representative collection of *P. aenigma* and of juvenile specimens of *P. horrida* is available for comparison, there must be some doubt about the conspecificity of the two species.

Should the validity of *Pauliella* need to be recognised, then a substitute name will have to be found since Ludwig's genus name is a homonym of *Pauliella* Munier-Chalmas, 1895 (Mollusca).

Genus **Amphiaster** Verrill, 1868

Amphiaster Verrill, 1868, p. 372; 1914, p. 294; Sladen 1889, p. 343; Ludwig, 1899, p. 689; Fisher, 1911, p. 170; Boone, 1928, p. 4; Spencer and Wright, 1966, p. U63.

DIAGNOSIS: Body form stellate, R/r = c.2.0; 4-5 superomarginal plates of similar size; distalmost superomarginal adjacent to the terminal plate and the opposite pairs at each arm tip are broadly contiguous above the terminal plate; abactinal plates with large, acute spine, h.d. 3 mm (at base) × v.d. up to 6 mm; actinal plates with 1-2 tubercles surrounded at the base by granules; intermarginal papulae few or absent; furrow spines 3-5 (usually 3); subambulacral spines in a single series.

TYPE-SPECIES: *A. insignis* Verrill, 1868 (by monotypy).

REMARKS: This genus is separated from *Paulia* on the basis of the arrangement of the superomarginal plates, the single series of subambulacral plates and the extension of the papulae to the inferomarginal line (at least in specimens where R = 38 mm and above). Whether this separation is justified is difficult to determine. Considering the amount of variation seen to occur in the genus *Asterodiscides*, it is thought that *Amphiaster* would probably fall under the range of variation which might be expected to be exhibited by *Paulia*. However, principally because of the lack of sufficient comparative material to clarify this issue, a conservative attitude is adopted here in respect of the recognition of these two genera.

Amphiaster insignis Verrill

A. insignis Verrill, 1868, p. 373, pl. IV fig. 10; 1914, p. 294, pl. XCVIII fig. 2; Ludwig, 1899, p. 689; H. L. Clark, 1913, p. 194; 1923, p. 150; Boone, 1928, p. 4, pl. 2; Spencer and Wright, 1966, p. U63

?*Nidorellia armata*, Brusca and Smith, 1973, p. 310, fig. 12.3. (non *N. armata* Gray, 1840).

DIAGNOSIS: As for genus.

DESCRIPTION: *A. insignis* has been well described by Verrill and is an easily recognised species. I have had the opportunity of examining three specimens collected from Lower California and identified by A. H. Clark (U.S.N.M. No. 3350). The smallest specimen (R = 27.5 mm) has four superomarginal plates whilst the two larger specimens (R = 38.5 mm and 50 mm respectively) have five. In the largest specimen, the innermost superomarginal of adjacent arms are contiguous, as are superomarginals 3-4 or 4-5 distalward along the arms, whilst 1-2, 2-3 and sometimes 3-4 are separated by a prominent spine-bearing plate. In the smallest specimen 2-3 are separated by a small plate and in the middle-sized specimen superomarginals 3-4 are likewise separated. There are six inferomarginal plates in the smallest specimen (R = 27.5 mm) and seven in the two larger. The proximal plates are flat but the distal 4 or 5 are either tumid or bear a stout spine on the actinal edge. The first inferomarginal plate of adjacent arms are in contact. Distalward, 1-2, 2-3, 3-4 and 4-5 on each arm are separated by a spine-bearing plate but 5-6 and 6-7 are contiguous. Each marginal plate has a peripheral ring of granules. The marginal series are separated by two vertically aligned large, spine-bearing plates, with a smaller plate between these adjacent pairs of plates. Some inferomarginal plates carry pedicellariae. Each actinal plate has a very prominent spine and three rings of granules. The adambulacral armament comprises 3 furrow spines and 1 subambulacral spine and accompanying peripheral granules. Papulae occur in groups of 5-6 and, at least in the two larger specimens a few extend to the inferomarginal line.

DISTRIBUTION: Lower California.

REMARKS: Verrill obviously mistook the number of superomarginal plates present, including the intercalating spine-bearing plates as marginals. He did not describe the presence of intermarginal papulae nor did he mention the intermarginal plates (which he considered as marginals).

This species has been recorded only a few times since it was described (H.L. Clark, 1913, 1923; Boone, 1928). Steinbeck and Ricketts (1941) did not meet with it on their travels in the 'Sea of Cortez'. More recently, Brusca and Smith (1973) recorded *Nidorellia armata* Gray from the Gulf of California. They described the living colour as a 'beautiful lavender to red-orange' and 'abora! spines usually purple with dark tips'. They mentioned that the star had heavy marginal plates and large, movable spines. It is unfortunate that the figure accompanying the description obviously represents *Amphiaster insignis*. It is difficult to decide which species was available to Brusca and Smith.

DISCUSSION

During an investigation of the genera described in this paper, two points became clear. Firstly, there have been varied opinions as to the true relationships between *Asterodiscides*, *Paulia* and *Amphiaster* and between them and members of the families Goniasteridae and Oreasteridae. Secondly, it is obvious that since Viguier, Perrier and Sladen each propounded their own methods of classifying asteroids, subsequent authors have used the combination of these three authors ideas to classify asteroids up to the present time. If one

continues to use the same method of classifying asteroids (none better has so far been devised) then it becomes clear that the combination of characters exhibited by *Asterodiscides, Paulia* and *Amphiaster* stand them apart from any other group of asteroids.

It would be extremely difficult to place the genera satisfactorily in either of Sladen's Phanerozonia or Cryptozonia because of the peculiar development of the marginal plates, the distribution of the papulae (to the inferomarginal line in *Asterodiscides* and *Amphiaster,* but only to the superomarginal line in *Paulia*) and the distinctive adambulacral armature. The armament of the abactinal and actinal plates seems also to be a distinctive feature of these three genera. In the systems of classification used, perhaps the weakest character to rely on is the form of the pedicellariae, because of absence of these organs from some specimens. However, when they are present it can be seen that the genera dealt with here fall in the Order Valvatida (spelling of the order adopted by Spencer and Wright). The arrangement of the marginal plates is absolutely distinctive and not known in any other group of asteroids. The armament of the abactinal and actinal plates and of the adambulacral plates is also distinctive, the only other genus with similarly armed plates being *Calliaster.* In this case it is very interesting to note that Spencer and Wright (1966) were unable to classify *Calliaster,* listing it, with *Amphiaster,* in the group of genera belonging to unnamed sub-families within the family Goniasteridae. The continuous margin of many, contiguous marginal plates, the low, squat form of the pedicellariae and the more varied occurrence of tubercles or spines on the abactinal plates immediately separates *Calliaster* from the genera dealt with here. I do not think that *Calliaster* can be placed in the same family as *Asterodiscides, Paulia* and *Amphiaster* but it should obviously be placed in a closely related family. Under Spencer and Wright's system the genera are included in the sub-order Granulosina, Order Valvatida, the main features of which are that the marginals are conspicuous, fewer than the adambulacrals and in two *opposite* series, the abactinal plates are not usually in a regular order in the adults, the plates usually bear spines or granules in shallow sockets and the pedicellariae, when present, are usually valvate and sunk in the ossicles. Within this higher grouping Spencer and Wright placed *Asterodiscides* and *Paulia* together in one family but were uncertain of the true affinities of *Amphiaster.* Although I agree with placing the three genera within the Order Valvatida, I consider that the diagnosis of the sub-order Granulosina has to be expanded to include these forms having *fewer* superomarginals than inferomarginals, *not* in two opposite series and spaced from each other horizontally and vertically; otherwise a new sub-order must be described. Within the sub-order Granulosina I do not believe that they can be placed in either of the families Goniasteridae or Oreasteridae, and propose the new family Asterodiscididae.

From the study of the fairly large collection on hand, it has been seen that young specimens resemble the goniasterids (particularly *Tosia*). Indeed adult *Amphiaster,* resembling *Calliaster,* may be considered as perhaps the least specialised member of the new family. In the juveniles the number of marginal plates is low (3-5) and does not usually increase from the number seen in the juvenile (the number at metamorphosis is not known, but is likely to be the same) except in *Amphiaster* where the number increases from four to five (see p.212).The distalmost superomarginal may be adjacent to the terminal plate or separated from it by one or two plates. Also, the distalmost superomarginal may be very large and prominent, larger than the other superomarginals. There is no evidence at present to suggest that the enlarged superomarginal is developed from a fusion of smaller plates during development, or that it has had any dominating effect on the development or distribution of either the remaining superomarginal plates or the inferomarginal plates. The proximal 2-3 superomarginals may become inconspicuous amongst the other skeletal plates. The number of inferomarginal plates exceeds that of the superomarginal plates, there being from 8-18 in adults of the species so far described. The number increases slightly with growth of the animal. The inferomarginals usually decrease regularly in size distalwards, with 4-9 underlying the large superomarginal at the end of the arm. Intercalary

plates separate the marginal plates from their adjacent neighbours both vertically and horizontally. The spacing of the marginal plates is not known in any group of genera. The spacing of the marginal plates would indicate a structural weakening of the margin of these asteroids. This appears to be compensated by the compactness of the abactinal skeleton and its thick, investing integument. The significance of this departure from a solid marginal boundary is not known, though it would certainly have facilitated the extension of the distribution of papulae to the inferomarginal line, and greater flexibility of the abactinal surface. Until more is known of the ecology of these asteroids little can be added that would not appear too speculative.

The abactinal plates, although appearing in contact in juvenile specimens, become separated but connected by radiating (usually 6) ossicles. These radiating ossicles can form into a dense supporting meshwork in larger animals, similar to that found in large specimens of oreasterids such as *Culcita*. Each of the abactinal plates usually bears a large central spine or tubercle surrounded at the base by one or two rings of granules. The skeleton, excluding the tubercles and granules which are covered by a thin epidermis, is invested by a thick integument.

Papulae occur in groups and may extend to the inferomarginal line. The presence of intermarginal papulae has been considered by Fisher (1911) to be sufficiently important to recognise the sub-family Nectrininae in the family Goniasteridae. He also noted the presence of superambulacral plates but does not appear to have considered these in relation to the recognition of the sub-family. Spencer and Wright diagnosed the sub-family Nectrininae using *both* of the characters. Certainly the presence or absence of papulae alone would make it difficult to justify recognising a sub-family when the distribution of papulae within the valvatulid family Ophidiasteridae is used only to separate genera. (It is interesting to note that the genus *Hacelia* Gray has superambulacral plates and has not so far been considered as belonging in anything other than the family Ophidiasteridae). I think, therefore, that there is no justification for splitting the new family into sub-families in order to distinguish *Paulia*, with its papulae confined abactinally above the superomarginal line, from *Asterodiscides* and *Amphiaster* with the papulae extending to the inferomarginal line.

The membranous interbrachial septum and absence of spicules from the tube-feet have been features considered by such recent authorities as Fisher, Döderlein and Spencer and Wright as being of sufficient importance to be used to distinguish the families Goniasteridae and Oreasteridae. In this regard the genera considered in this paper cannot be placed in the latter family. The adambulacral armature is distinctive in that each plate bears a furrow fan backed across the plate by 1 or 2 + 0 or 1 (rarely 2) + 0 or 1 large, truncate subambulacral spines, the rest of the plate bearing prismatic granules. I have been able to find a similar arrangement of adambulacral armament only in the genus *Calliaster* which Spencer and Wright (1966) were unable to assign (as was the case with *Amphiaster*) to a sub-family within the family Goniasteridae. The shape of the pedicellariae is closer to those of *Pentagonaster* than to those found in the Oreasteridae, but some specimens may lack pedicellariae altogether.

The R/r ratio remains relatively constant from juvenile through to adult. Each of the species of *Asterodiscides* described in this paper is well marked. It is probable that the full specific potential of the genus is not yet realised, when the number of specimens available and their scattered distribution is considered. This must be particularly apparent when it is seen that the specimens from practically each of the separate localities collected appear to represent separate species or sub-species.

The characters used in the classification of the Order and Sub-order and in the argument to establish the new family, to which *Asterodiscides* belongs have been outlined, in some detail, above. The characters used to distinguish between the species have been:

1. R/r ratio.
2. Shape of the abactinal and actinal tubercles.
3. Relative size of the distalmost superomarginal plate to the proximal 2-3 superomarginal plates, number of superomarginal and inferomarginal plates.
4. Relative amount of contact between adjacent superomarginal plates at the tip of the arm, including the relationship between the distalmost superomarginal plate and the terminal plate; shape of the distalmost superomarginal plate.
5. Specific furrow spine number and extent of subambulacral armament.

These features have grouped several species closer to each other than to some of the other species, as can be seen in the dichotomous key: e.g. *tessellatus* and *helenotus; elegans* and *culcitulus; tuberculosus, grayi* and *lacrimulus; pinguiculus* and *truncatus* appear to stand alone. I do not think that these groupings should be considered, at least at the present time, to represent higher taxonomic (generic) groupings, since this would involve the erection of one or more monotypic genera, thus indicating that too much weight *may* have been placed on the characters used to establish those genera.

The inclusion of *Paulia* and *Amphiaster* in the same family with *Asterodiscides* has been justified above. The retention of those genera as valid supra-specific taxa distinct from *Asterodiscides* is justified here on two major points; the form of the plates armature and the arrangement of the superomarginal plates. The limited extent of the intermarginal papulae may also be a feature used to distinguish these two from *Asterodiscides.* The lack of intermarginal papulae and the different arrangement of the superomarginal plates and the number of series of subambulacral spines are features used to separate *Paulia* from *Amphiaster.*

No overriding character or characters have been seen in the Indo-west Pacific Ocean specimens, on which to place reliable generic weight. This is probably principally due to the low number of specimens obtained from each locality (except for *A. culcitulus,* which has, in fact, shown how relatively constant the features of a species may be) and the distinctness of each of the local phenotypes. Until more material is available from the same and from intermediate localities, it is considered that, despite some apparent inconsistency in the taxonomic weight placed on some of the characters exhibited by these asteroids, a conservative attitude should be adopted towards retaining presently accepted taxa and the establishment of new taxa.

The distribution of the Asterodiscididae appears to be generally tropical-sub-tropical Indian and Pacific Oceans, with the notable exception of *Asterodiscides truncatus* from the more temperate southeastern Australia and northern New Zealand waters. It is perhaps interesting that *Paulia* and *Amphiaster* are restricted to the extreme eastern, tropical area of the Pacific (Galapagos — Lower California — Peru) and that these seem to be the least specialised forms of the family. *Asterodiscides,* with the exception of *A. truncatus,* extends through the Indian Ocean to the northeastern coast of Australia and northward to the Philippine Islands and to southern Japan. It extends east to the Hawaiian Islands in the north and to the Kermadec Islands in the south Pacific but has not so far been found in the East Indies region or from the islands of the central Pacific. *Paulia* and *Amphiaster* can be collected from shore line to about 20-30 m depth whereas *Asterodiscides* occurs down to about 792 m, though more usually around 50-100 m, and has only once been recorded as occurring on the shore.

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List of Specimens Examined

No. specimens	Locality and Remarks	R/r = mm
	Asterodiscides culcitulus n. sp.	
1	Stn 104, 29°29'S, 114°12'E, W.S.W. Dongara, Western Australia, 108 m., 8.xii.70, H.M.A.S. 'Diamantina'. HOLOTYPE W.A.M. 1063-74	54/49
11	Stn 107, 30°29'S, 114°40'E, S. W. of Jurien Bay, Western Australia, 144 m, 9.xii.70, H.M.A.S. 'Diamantina'. PARATYPES W.A.M. 1116-74	34-57.7/ 26.5-47.7
1	Shark Bay, Western Australia, trawled, 6/63, colld W. and W. Poole. W.A.M. 1078-74	97/75
1	Stn 55, off Pelsart Group, Western Australia, 180 m, 16.ii.64, H.M.A.S. 'Diamantina'. W.A.M. 1077-74	93/71.5
1	Cottesloe, 40 km W. of Fremantle, Western Australia, c90 m in crayfish pot, 23.i.64, Mr Lyon. W.A.M. 1069-74	83/63
8	Stn 107, 30°29'S, 114°40'E, S.W of Jurien Bay, Western Australia, 144 mm, 9.xii.70, H.M.A.S. 'Diamantina'. W.A.M. 118-74	26-63/22-54
13	Stn 107, 30° 29'S, 114°40'E, S. W. of Jurien Bay, Western Australia, 144 mm, 9.xii.70, H.M.A.S. 'Diamantina'. W.A.M. 1117-74	13.5-57.7/ 11.5-44.5
2	Stn 109, 30°29'S, 114°40'E, S.W. of Jurien Bay, Western Australia, 100 m, 9.xii.70, H.M.A.S. 'Diamantina'. W.A.M. 1120-74	18.5-47.5/ 13.5-37.8
1	Stn 68/1, 30°37'S, 114°44'E, Western Australia, 139-146 m, 22.iii.72, H.M.A.S. 'Diamantina', W.A.M. 1072-74	45/39
2	Stn 41, 30°38'S, 114°46'E, N.W. of Green Is. Western Australia, 144 m, 27.xi.70, H.M.A.S. 'Diamantina'. W.A.M. 1064-74	22-41/32-34

4	Continental shelf between Cape Naturaliste and Shark Bay, Western Australia. December 1970, H.M.A.S. 'Diamantina'. W.A.M. 1071-74	33.5-40/ 30-40
1	Stn 46, off Lancelin Is, Western Australia, 117 m, 5.ii.64 H.M.A.S. 'Diamantina'. W.A.M. 1073-74	38/33.7
1	Stn 68/3, 30°34'S, 114°44'E, N.W. of Green Is, Western Australia, 128 m, 22.iii.72, H.M.A.S. 'Diamantina'. W.A.M. 1123-74	36.5/29.5
3	Stn 55, 29°15'S, 114°01'E, West of Dongara, Western Australia, 146 m, 20.iii.72, H.M.A.S. 'Diamantina'. W.A.M. 1068-74	22-34.5/ 18.6-28
1	Stn 80, 27°35'S, 114°04'E, W. of Gautheaume, Western Australia, 114 m, 6.xii.70, H.M.A.S. 'Diamantina'. W.A.M. 1121-74	33/27.5
1	Stn 46, off Lancelin Is, Western Australia, 117 m, 5.ii.64, H.M.A.S. 'Diamantina'. W.A.M. 1074-74	31/25
2	Stn 37, 30°55'S, 114°48'E, W. of Lancelin Is, Western Australia, 144 m, 26.xi.70, H.M.A.S. 'Diamantina'. W.A.M. 1065-74	14-31/ 11-26.5
2	N.W. of Rottnest Is, Western Australia, 144 m, 15.ix.65, 'Bluefin'. W.A.M. 1066-74	13.7-27.5/ 10.5-23.5
2	Stn 8, 32°57.5'S, 114°48'E, Western Australia, 122-139 m, 15.iii.72, H.M.A.S. 'Diamantina'. W.A.M. 1070-74	18.0-23.0/ 14.5-18
1	Stn 55, 29°15'S, 114°01'E, W. off Dongara, Western Australia, 139-146 m, 20.iii.72, H.M.A.S. 'Diamantina'. W.A.M. 1122-74	20/16
1	Between 30°34'S and 34°04'S, Western Australia, 45-180 m, 23-8.xi.70, H.M.A.S. 'Diamantina'. W.A.M. 1067-74	19.5/14.5
1	Stn 56, 29°18'S, 114°04'E, Western Australia, 170-174 m, 10.iii.72, H.M.A.S. 'Diamantina'. W.A.M. 1075-74.	14.5/12.5
1	Stn 68/1, 30°37'S, 114°44'E, Western Australia, 139-146 m, 22.iii.72, H.M.A.S. 'Diamantina'. W.A.M. 1076-74	14.5/12.5
1	Stn 46, off Lancelin Is, Western Australia, 117 m, 5.ii.64, H.M.A.S. 'Diamantina'. W.A.M. 1084-74	13/9.5
1	W.N.W. of Rottnest Is, Western Australia, 171-173, 14.viii.62, colld R. W. George. W.A.M. 1088-74	12.5/9.5
1	Stn 46, off Lancelin Is. Western Australia, 117 m, 5.ii.64, H.M.A.S. 'Diamantina'. W.A.M. 1083-74.	12/9.3
2	Stn 46, off Lancelin Is, Western Australia, 113-120 m, 1964, H.M.A.S. 'Diamantina'. W.A.M. 1124-74	11.5/8.5

1	Stn 46, off Lancelin Is, Western Australia, 117 m, 5.ii.64, H.M.A.S. 'Diamantina'. W.A.M. 1087-74	11/8.5
1	As above. W.A.M. 1085-74	10/8.3
1	As above. W.A.M. 1082-74	10/7.6
1	As above. W.A.M. 1086-74	6.5/4.5
	A. elegans elegans (Gray)	
1	No locality, Purchd. Argent. HOLOTYPE. B.M. 1845.3.5.353	36/24
1	'N. China', Purchd Fortune, Figured by Gray, 1866, pl.12, fig. 2. B.M. 1847.6.18.4	24/16
1	'Albatross' stn 5482, between Samar and Leyte, vicinity of Surigar Strait, Philippine Islands, 120 m, 30.vii.09. U.S.N.M. 40544	36/24
1	'China', Purchd Cuming. B.M. 1849.1.31.4	62/47
1	'N. China', Purchd Cuming. B.M. 1849.1.31.3	64/49
1	Zamboangan, Philippine Islands, 18 m, 'Challenger' Expedition. B.M. 1890.5.7.501	90/67
	A. elegans belli n. subsp.	
1	Amirante Is, Western Indian Ocean, 46 m, Stanley Gardiner Expedition. HOLOTYPE. B.M. 1907.7.1.46	62.7/47
1	As above, 80 m. PARATYPE formerly B.M. 1907.7.1.44, donated to the Australian Museum, J9734	68/60
1	Saya da Malha, Western Indian Ocean, Stanley Gardiner Expedition. B.M. 1907.7.1.45 (part)	60/44
2	Madras, India, colld E. Thurston. B.M. 1890.1.13.11-12 (part), A.M.J.9735 (one donated to The Australian Museum)	65.5/50 (A.M.) 83/73 (B.M.)
	A. truncatus (Coleman)	
1	Off Coast of New South Wales, Australia, F.I.S. 'Endeavour' SYNTYPE. A.M. J1053	104/48
1	Off East Coast of Victoria, Australia, F.I.S. 'Endeavour' SYNTYPE. A.M. J2047	131/61
1	Tollgate Ids, Bateman's Bay, New South Wales, Australia, 6.x.57, B. Dew and E. Slater. A.M. J6910	44/20
1	Off Norah Head, New South Wales, Australia, 47-68 m, McNeil and Livingstone. A.M. J3476	70/30

2	Tollgate Ids, Bateman's Bay, New South Wales, Australia, intertidal, E. Slater. A.M. J6977	71-73/33-34
1	Bass Point, New South Wales, Australia, 30 m, sponge and coral cover, 23.3.75, B. Clark. A.M. J9179	86/46
1	Off Norah Head, New South Wales, Australia, 47-68 m, McNeil and Livingstone. A.M. J3474	87/40
1	Great Australian Bight, 144-216 m, F.I.S. 'Endeavour' A.M. E3641	92/38
1	As above. A.M. J3071	101/47
1	4-6.4 km off Botany Bay, New South Wales, Australia, 59-101 m, Livingstone and Fletcher. A.M. 3865	102/48
1	As above. A.M. J3868	102/48
1	As above, McNeil and Livingstone, A.M. J3489	105/49
1	Off Norah Head, New South Wales, Australia, 47-68 m, McNeil and Livingstone. A.M. J3473	108/47
1	4-6.4 km off Botany Bay, New South Wales, Australia, 59-101 m, Livingstone and Fletcher, A.M. J3867	111/55
1	As above, A.M. J3866	115/56
1	Terrigal, New South Wales, Australia, 19 m, 24.vi.65. colld R. Dawson, don. J. Campbell. A.M. J8767	115/50
1	Off Norah Head, New South Wales, Australia, 47-68 m, McNeil and Livingstone. A.M. J3475	115/50
1	As above. A.M. J3472	118/48
1	Terrigal, New South Wales, Australia, 20 m, 24.vi.65, colld R. Dawson, don. J. Campbell. A.M. J8764	118/51
1	Off Norah Head, New South Wales, Australia, 47-68 m McNeil and Livingstone. A.M. J3470	121/55
1	4-6.4 km off Botany Bay, New South Wales, Australia, 59-101 m McNeil and Livingstone. A.M. J3491	121/57
1	19.2-35.2 km N., 0.8 km E. from Green Cape, New South Wales, Australia, 70-83 m, Livingstone and Fletcher. A.M. J4594	127/61
1	As above. A.M. J4595	129/56

1	As above A.M. J4596	138/63
2	32 km E. of Broken Bay, New South Wales, Australia, 774-792 m, 2.iv.75, F.I.S. 'Kapala'. A.M. J9173	110-135/ 55-60
1	Eastern slope of Bass Strait, Australia, 144-360 m, F.I.S. 'Endeavour'. A.M. J4680	152/81
2	Locality unknown, F.I.S. 'Endeavour'. A.M. E5284-5	141-159/74-76
1	9.6 km east of Cape Hawke, New South Wales, Australia, 84-90 m F.I.S. 'Endeavour'. M.C.Z. 2484 (formerly A.M. E1645, donated to M.C.Z.). Labelled 'Cotype' but see p.	80/40
1	Stn 56, Botany Bay, New South Wales, Australia, 14.2-144 m, H.M.C.S. 'Thetis'. M.C.Z. 1998. Labelled 'Cotype' but see p.	126/55
1	Great Australian Bight, 162 m, D. L. Serventy. M.C.Z. 3174	70/35
1	Eastern Slope, Bass Strait, Australia, 144-360 m, F.I.S. 'Endeavour'. M.C.Z. 2483 (formerly A.M. J4679, donated to M.C.Z.)	150/73
1	Auckland, New Zealand, 1964, John Graham, U.S.N.M. E10144	c.82/42.5
1	Raoul Is, Kermadec Islands, N. of New Zealand, A. N. Baker, N.M.N.Z. ECH1281	64/32
	A. helenotus (Fisher)	
1	Stn 5149, off Sirum Id, vicinity of Siasi, Sulu Archipelago, Philippine Is., 18 m, U.S.F.S. 'Albatross'. HOLOTYPE U.S.N.M. 32633	98/48
1	Sulu Archipelago, Philippine Is., 52 m, sand and *Lithothamnion*, 22.II.64, B. R. Wilson. W.A.M. 1081-74	14.4/8.6
1	As above. 72-81 m, sponge and *Lithothamnion*, 22.II.64, B. R. Wilson. W.A.M. 1080-74	16.4/8
	A. tessellatus n. sp.	
2	Saya da Malha, western Indian Ocean, 99 m., Stanley Gardiner Expedition. HOLOTYPE and PARATYPE. B.M. 1907.7.1.45 (part)	40-46.6/18.5 (Holotype) 33-35/17.5 (Paratype)
	A. pinguiculus n. sp.	
1	N.E. of Bernier Is., Shark Bay, Western Australia, 23-27 m, 25.vi.71, D. Heald, HOLOTYPE. W.A.M. 1079-74 1079-74	92.5/58.5

1	Exmouth Gulf, Western Australia, 7-20 m, 1-8.v.76, J. Pennon 'Flinders' W.A.M. 361-76	61/41
	A. lacrimulus n. sp.	
1	Stn 444, Cruise 9, 09° 36'N, 51° 01'E. (off Socotra, N.W. Indian Ocean), 78-82 m, 16.xii.64, 'Anton Bruun' (I.I.O.E.) HOLOTYPE. U.S.N.M. E15833	57.5/37.5
1	Stn 463, Cruise 9, 11°24'N, 51°35'E. (off Socotra, N.W. Indian Ocean), 75-175 m, 17.xii.64, 'Anton Bruun' (I.I.O.E.) PARATYPE A.M. J9792	68/46
	A. tuberculosus (Fisher)	
1	Stn 3940, vicinity of Laysan Isd., Hawaii, 106-126 m, white sand and broken shell, bottom temperature 70°F, 16.vi.02, U.S.F.S. 'Albatross'. HOLOTYPE. U.S.N.M. 21172	69/40
1	1.6 km off Rabbit Isd, Oahu, Hawaii, 59-61 m, 14.iv.49, Brock B.P.B.M. W1148	7.5/5
	A. grayi n. sp.	
1	Stn 2, 27°27'22"S, 153°39'E, Moreton Bay, Queensland, 75 m, 29.3.69, 'Kimbla' (Dr Ponder). HOLOTYPE. A.M. J8719	c.65/30
1	Raoul Isd, Kermadec Is, N. of New Zealand, A. N. Baker. N.M.N.Z. ECH 1280	75/37
2	Norfolk Island, N.Z.O.I., Stn 190, 29°25'S, 168°05.6'E, 71 m, 23.7.75	62-65/ 35-36
	Paulia horrida Gray	
1	Stn 330-35, Tagus Cove, Albemarle Id, Galapagos Is, 21 m, 10.xii.30, 'Velero' (Allan Hancock Foundation) A.M. J9654	60/31
	Amphiaster insignis Verrill	
3	Lower California. U.S.N.M. 3350	27.5-50 (r not taken)

FIGURE 1. — A-C, *Asterodiscides culcitulus* n. sp., holotype, a. abactinal, b. lateral, c. actinal views, R = 54mm, W.A.M. 1063-74. D-H. *A. culcitulus* n.sp., abactinal views, d. R = 6.5mm, W.A.M. 1086-74, e. R = 10mm, W.A.M. 1082-74, f. R = 12.5mm, W.A.M. 1088-74, g. R = 14.5mm, W.A.M. 1075-74, h. R = 38mm, W.A.M. 1073-74. I-K. *A. culcitulus* n. sp., i. abactinal, j. lateral, k. actinal views, R = 93mm, W.A.M. 1077-74.

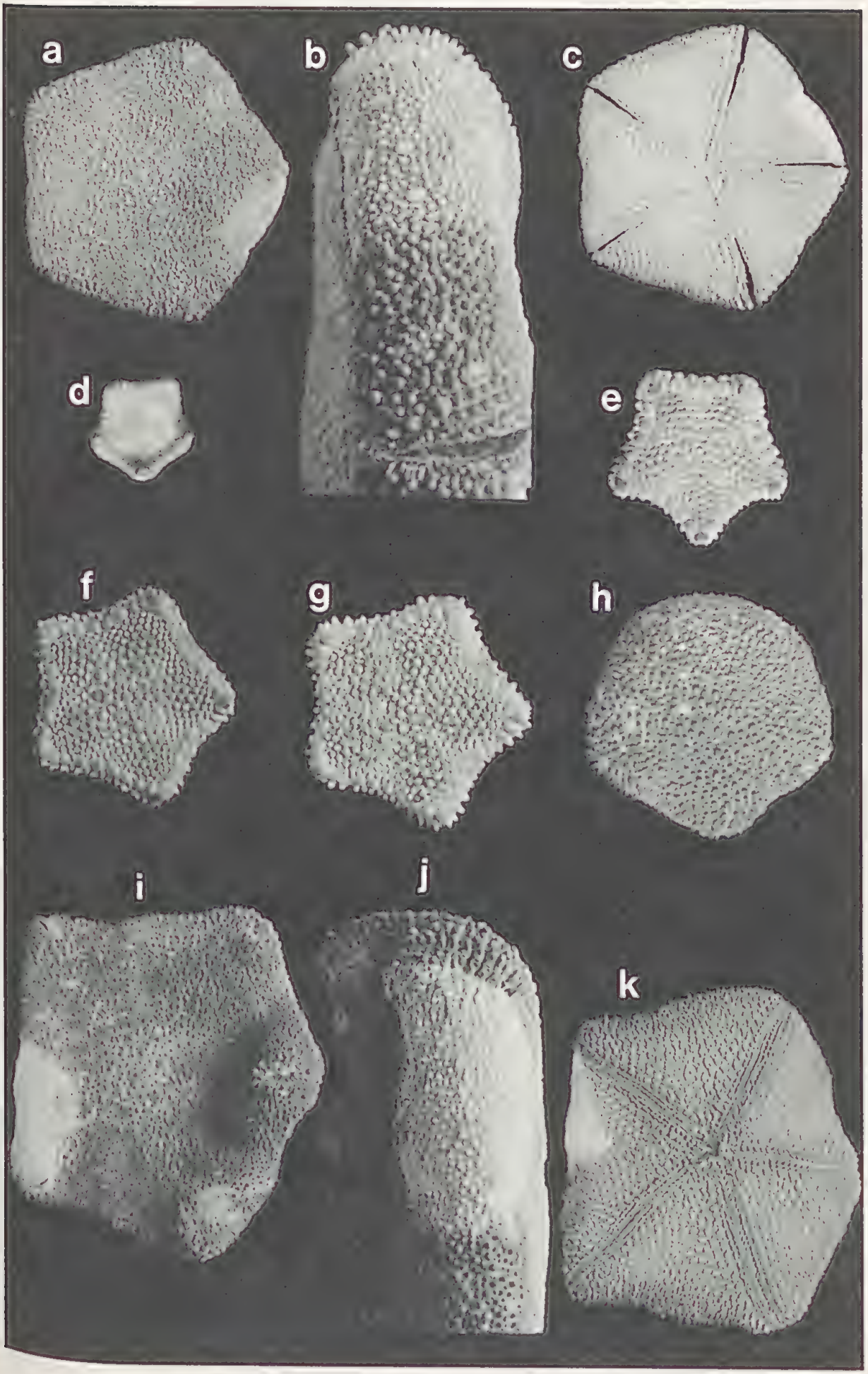
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FIGURE 2. — A-C. *Asterodiscides elegans elegans* (Gray), holotype, a. abactinal, b. lateral, c. actinal views, R = 36mm, B.M. 1845.3.5.353. D-E. *A. elegans elegans* (Gray), d. abactinal, e. lateral views, R = 36mm, U.S.N.M. 40544. F-H. *A. elegans elegans* (Gray), f. abactinal, g. lateral, h. actinal views, R = 24mm, B.M. 1847.6.18.4. I. *A. elegans elegans* (Gray), lateral view, R = 64mm, B.M. 1849.1.31.3. J. *A. elegans elegans* (Gray), abactinal view, R = 90mm, B.M. 1890.5.7.501.

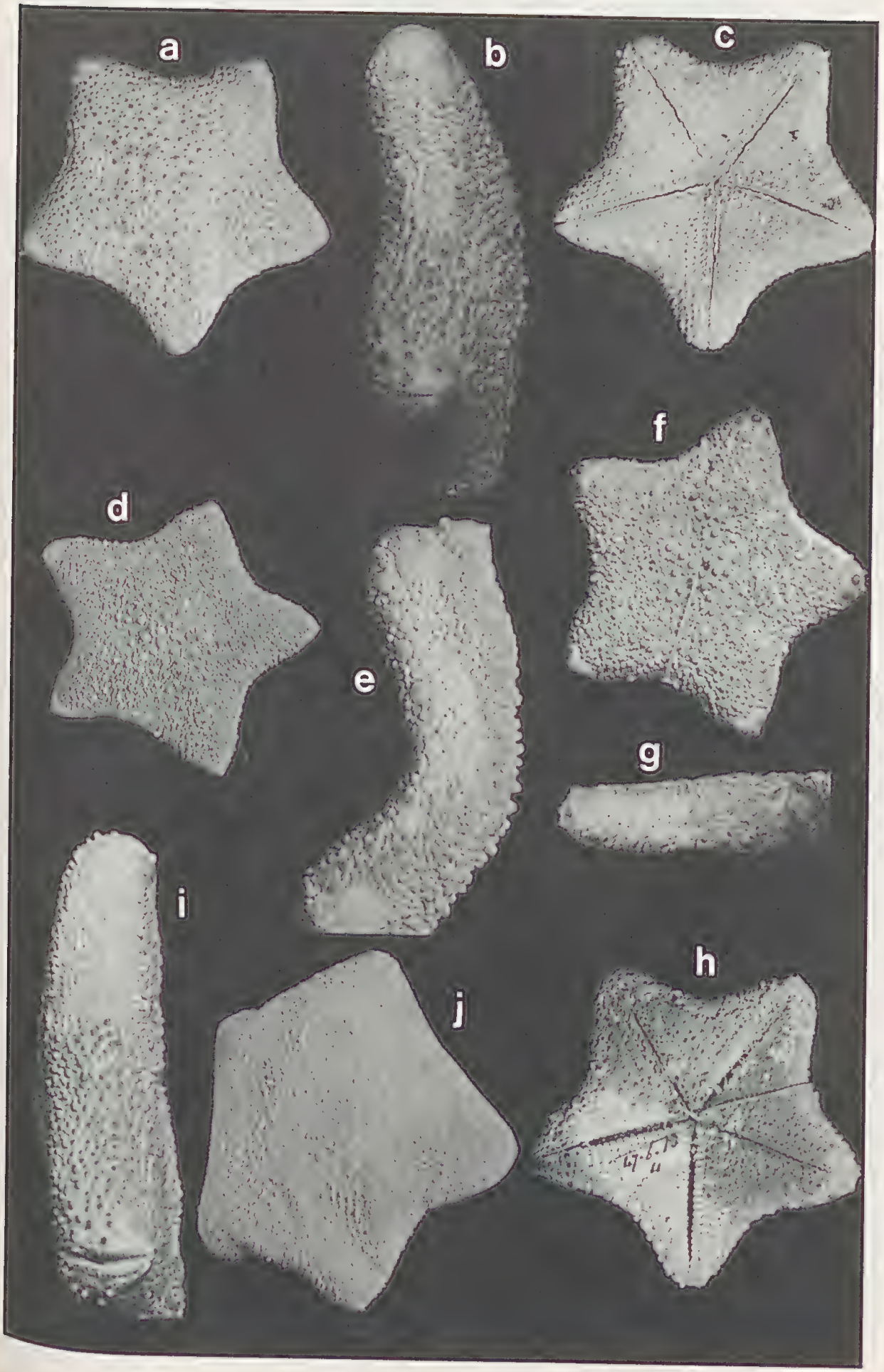
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FIGURE 3. — A-B. *Asterodiscides elegans belli* subsp. nov., holotype, a. abactinal, b. lateral views, R = 62.7mm, B.M. 1907.7.1.46. C-D. *A. elegans belli* n. subsp., c. abactinal, d. actinal views, R = 65.5mm, A.M. J9735. E-G. *A. truncatus* (Coleman), syntype, e. abactinal, f. lateral, g. actinal views, R = 104mm, A.M. J1053. H-I. *A. helenotus* (Fisher), holotype, h. abactinal, i. lateral views, R = 98mm, U.S.N.M. 32633.

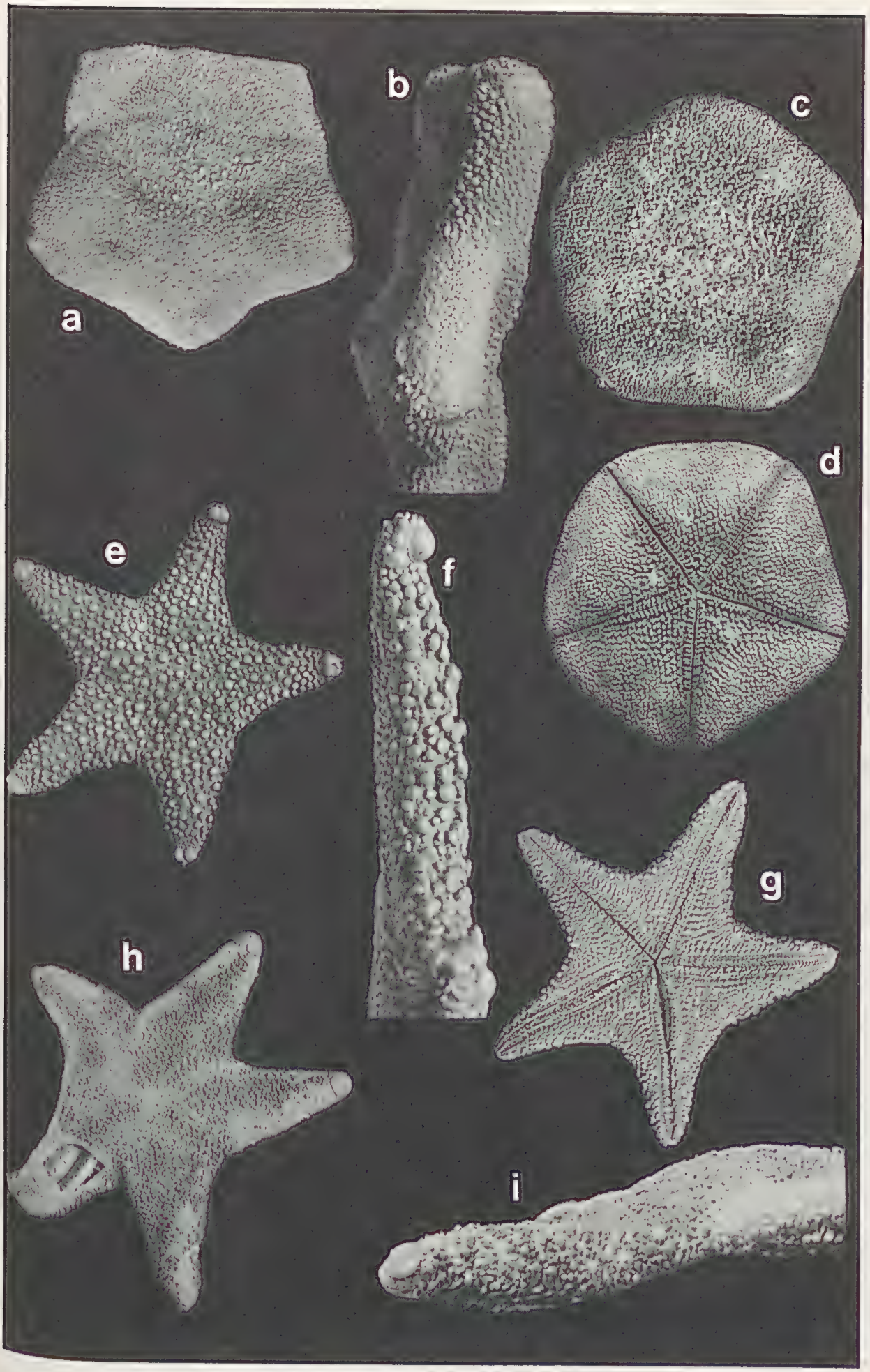
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FIGURE 4. — A. *Asterodiscides helenotus* (Fisher), holotype, actinal view, R = 98mm, U.S.N.M. 32633. B. *A. helenotus* (Fisher), juvenile, abactinal view, R = 16.4mm, W.A.M. 1080-74. C-E. *A. tessellatus* n. sp., holotype, c. abactinal, d. oblique abactinal, including partially denuded arm, e. actinal, partially denuded arm, R = 40 — 46.6mm, B.M. 1907.7.1.45 (part). F-G. *A. tessellatus* n. sp., paratype, f. abactinal, g. actinal views, R = 33-35mm, B.M. 1907.7.1.45 (part). H-J. *A. pinguiculus* n. sp., holotype, h. abactinal, i. lateral, j. actinal views, R = 92.5mm, W.A.M. 1079-74.

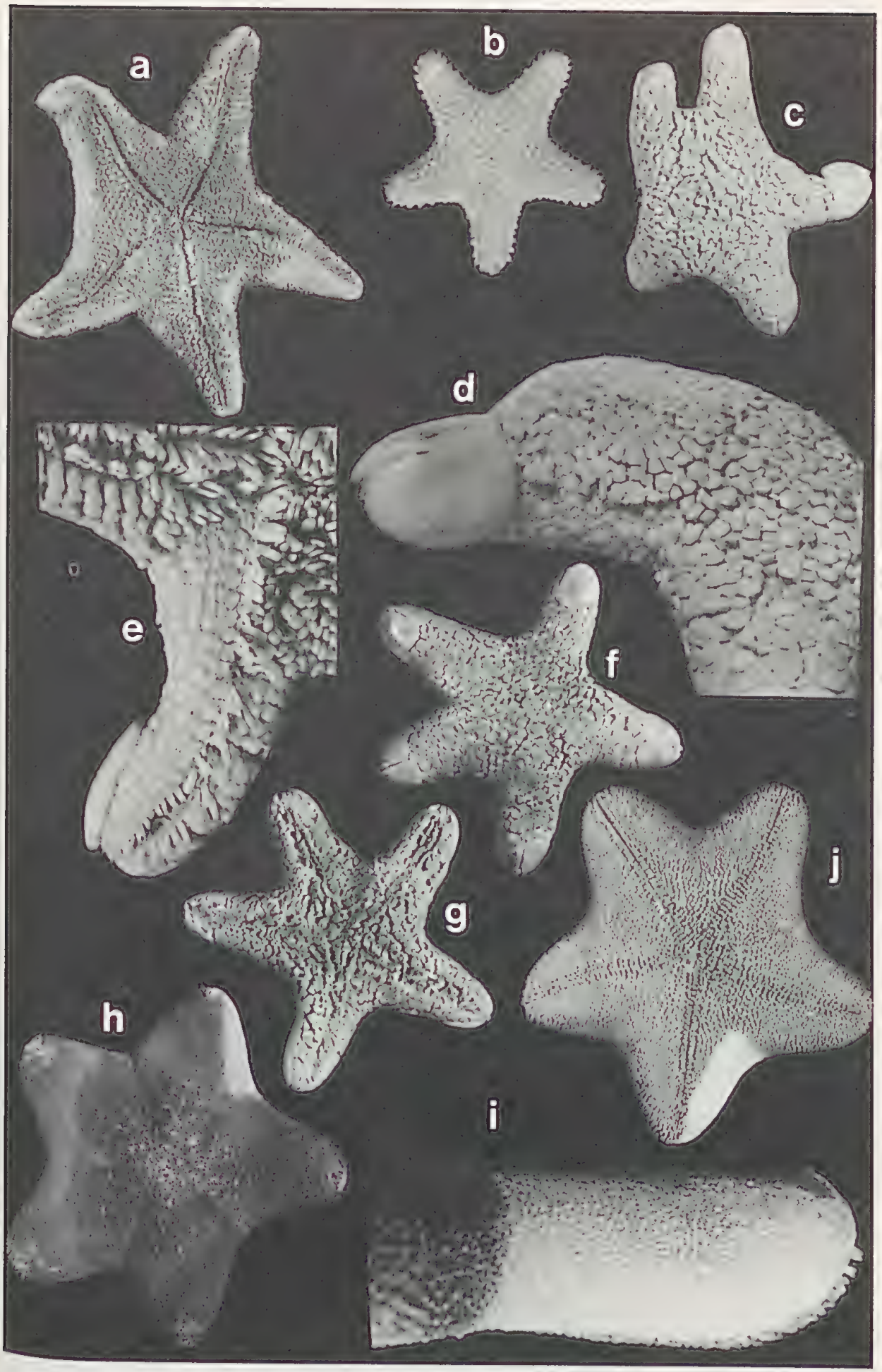
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FIGURE 5. — A-C. *Asterodiscides lacrimulus* n. sp., holotype, a. abactinal, b. lateral, c. actinal views, R = 57.5mm, U.S.N.M. E15833. D. *A. tuberculosus* (Fisher), holotype, Lateral view, R = 69mm, U.S.N.M. 21172. E-F. *A. grayi* n. sp., holotype, e. abactinal, f. oblique actinal views, R = 65mm, A.M. J8719. G-I. *Paulia horrida* Gray, g. abactinal, h. lateral, i. actinal views, R = 60mm, A.M. J9654.

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THE STATUS OF *NARDOA (ANDORA)* A. M. CLARK, 1967 (ASTEROIDEA: OPHIDIASTERIDAE), WITH THE DESCRIPTION OF TWO NEW SUBGENERA AND THREE NEW SPECIES

F. W. E. ROWE

The Australian Museum, Sydney.

SUMMARY

The diagnosis of *Nardoa (Andora)* A. M. Clark is expanded and this subgenus of *Nardoa* is elevated to generic rank. Two new subgenera of *Andora* and three new species are described, extending the distribution of the genus from the Arabian Sea to the Mozambique Channel, Heron Island (east coast of Australia) and the Philippine Islands.

INTRODUCTION

Macan (1938) described the species *Nardoa faouzii* from a single specimen collected in shallow-water from off the Arabian coast during the John Murray Expedition (1933-4). The species has not been re-encountered. A. M. Clark (1967) re-examined the holotype and concluded that the regular arrangement of the abactinal plates on the proximal one third of the arms was a character of sufficient weight to distinguish *faouzii* subgenerically from *variolata* (type-species of *Nardoa;* designated by H. L. Clark, 1921) and other species included in the genus *Nardoa* in the same paper. She accordingly defined *Andora* as a subgenus of *Nardoa.*

While preparing a revision of the genus *Nardoa,* I have had the opportunity of examining the holotype of *Nardoa (Andora) faouzii* Macan as well as undescribed specimens from Mozambique Channel (Western Indian Ocean), the Philippine Islands, and from Heron Island (Queensland coast, Australia). The combination of characters exhibited by these five specimens shows them not only to represent four distinct species (three of them new) but that the species are clearly related within the common supra-specific taxon *Andora.* I believe that the taxon *Andora* is sufficiently distinguishable from other related ophidiasterid genera to be elevated to generic level, and that within this taxon two subgeneric taxa should be recognised.

Records of The Australian Museum, 1977, **Vol. 31 No. 6**, 235-245 Figures 1-2

SYSTEMATIC ACCOUNT

Genus **Andora** A. M. Clark

Nardoa (Andora) A. M. Clark, 1967, p. 187.

DIAGNOSIS: A genus of ophidiasterid with the primary plates distinct; transversely rectangular abactinal plates contiguous and aligned longitudinally and transversely along only 1/3R, distal to which the plates of the carinal and first abactinal-lateral row on each side are of irregular shape and arrangement many being larger than the proximal plates, the plates of the second abactinal-lateral rows can usually be traced to within a short distance of the arm tip, other abactinal-lateral rows of plates extend for a short distance from the base of the arms; number of infero- and superomarginal plates equal or inferomarginal number exceeds superomarginal number by about 50%; marginal plates decrease in size uniformly distally; papulae occur abactinally, intermarginally and actinally (actinal papulae are absent in juvenile specimens, R = 20 mm); granules usually polygonal in cross-section, closely covering all external surfaces; adambulacral plates with 3-5 furrow spines and 3-5 subambulacral spines in two distinct rows, a third row formed by granules is barely distinguishable from the actinal granulation except in the type species of the genus, the furrow and subambulacral spines may be truncate or bevel-tipped; no pedicellariae (on specimens so far examined).

TYPE SPECIES: *Nardoa faouzii* Macan: as designated by A. M. Clark, 1967.

REMARKS: This genus is closest to *Nardoa* from which it may be most readily distinguished by the arrangement of the abactinal plates. Where there is some regular alignment of proximal abactinal plates in *Nardoa* the plates are not contiguous or of the same distinctive shape as those found in *Andora*. The shape and arrangement of the adambulacral armature seems also to be distinctive, at least for three out of the four species. *Andora* is distinguished from *Heteronardoa* and *Certonardoa* also by the distribution of the papulae. Juvenile specimens of *Andora*, lacking papulae actinally, may be distinguished from *Gomophia* by the lack of tuberculate plates and the uniform decrease in size of the marginal plates towards the tip of the arms, there being no alternation of marginal plate sizes and from *Certonardoa* by the restriction of the regularly aligned abactinal plates to the basal portion of the arms.

Andora subgen. sensus novo

DIAGNOSIS: A subgenus of *Andora* with the number of inferomarginal and superomarginal plates equal.

TYPE SPECIES: *Nardoa faouzii* Macan; herein designated.

OTHER SPECIES INCLUDED: *Andora (Andora) bruuni* sp. nov.

Dorana subgen. nov.

DIAGNOSIS: A subgenus of *Andora* with the number of inferomarginal plates exceeding the number of superomarginal plates by about 50%.

TYPE SPECIES: *Andora (Dorana) wilsoni* sp. nov.; herein designated.

OTHER SPECIES INCLUDED: *Andora (Dorana) popei* sp. nov.

KEY TO THE SUBGENERA AND SPECIES OF *Andora*

1. Superomarginal and inferomarginal plates of similar number; R/r = 5.3-6.2 ..... *Andora* subgen. sensus novo 2.
— Inferomarginal plates exceed superomarginal plates, in number, by 50%; R/r = 6.75-7.0 ..... *Dorana* subgen. nov. 3.
2. Primary plates separated by small plates, primaries up to 2.75 mm diameter; distal abactinal plates circular in outline, up to 2 mm maximum diameter; furrow spines truncate, round-tipped; Arabian Sea ..... *A. (A.) faouzii* (Macan)
— Primary plates contiguous, up to 3.5 mm diameter; distal abactinal plates usually transversely oval or diamond-shaped, up to 3.0 mm maximum diameter; furrow spines with bevelled tip; Mozambique Channel ..... *A. (A.) bruuni* sp. nov.
3. Arrangement of proximal abactinal arm plates not clearly defined; distal plates of two distinct sizes, largest more or less circular up to 2.5 mm maximum diameter; two abactinal-lateral rows; Philippine Islands ..... *A. (D.) wilsoni* sp. nov.
Arrangement of proximal abactinal arm plates clearly defined; distal plates irregularly shaped but most longitudinally oval, not in two distinct sizes, up to 3.75 mm maximum diameter; three abactinal-lateral rows; Heron Island (eastern coast of Australia) ..... *A. (D.) popei* sp. nov.

A. (Andora) faouzii (Macan)
Fig. 1a-c

Nardoa faouzii Macan, 1938, p. 407, pl. I figs 8-9.

N. (Andora) faouzii. — A. M. Clark, 1967, p. 187.

MATERIAL EXAMINED: 1 specimen (holotype): stn 53, Arabian Sea, 13.5 m, John Murray Expedition, 1933-4; B.M. (N.H.) no. 1937.6.18.306, British Museum (Natural History), London, England.

DESCRIPTION: The holotype has five arms, R = 48.5-54 mm, r = 9 mm, R/r = 5.3-6.0. Central-dorsal plate oval, 3.0 mm × 2.5 mm. Five inner radial plates round to oval, maximum diameter = 2.75 mm, spaced from each other and (with the exception of one radial plate) from central-dorsal plate by one or two small plates. Five interradial plates also round to oval, maximum diameter (extending into the interradius) = 3.0 mm, each separated from inner radial and outer radial (i.e. first carinal) plates of adjacent radii by one or two small plates. Each interradial contiguous with first plate of first abactinal-lateral row of plates of adjacent arms and a small plate below, which continues second abactinal lateral row of adjacent arms into a continuous series of plates around the interradial arch. One interradial plate carries madreporite. First carinal plate (i.e. outer radial) D-shaped, maximum transverse diameter = 3.0 mm. Along abactinal side of each arm a carinal row of 4-5 plates, each plate = 2 mm (transverse diameter) × 1.75 mm (longitudinal diameter) (except for the first carinal plate). There are four abactinal-lateral rows. First 4-5 plates of the carinal and abactinal-lateral rows longitudinally and transversely aligned. Distally, second abactinal-lateral row extends to within about 10 mm of arm tip, third row extends to about 2/3R and fourth row only to about 1/2R. Carinal and first abactinal-lateral row (on each side of the carinal) irregularly arranged. These plates more or less circular in outline, decreasing evenly in size towards tip of the arms. Maximum diameter of circular plates = 2 mm, not larger than plates on proximal part of arm, fig. 1a.

The 26 superomarginal plates are squarish (the fifth measures 2 mm × 2 mm) and decrease in size evenly distally. The 26-27 inferomarginals are of similar dimensions to superomarginal plates, fig. 1c.

Three, with indication of fourth, rows of actinal plates. First row, adjacent to adambulacral plates, extends to within 5-7 mm from arm tip with two plates corresponding to each inferomarginal plate. Second row comprises 4 plates; third row 2-3 plates and fourth a single plate, fig. 1b.

Papulae in groups of up to 8 between abactinal plates, up to 12 between marginal plates and up to 8 between inferomarginal and actinal plates. Granules polygonal in cross section, close fitting, but most abactinal plates rubbed bare. Granules are of mixed size but towards centre of plates many are larger than granules at the periphery (c.6-7/mm: c.10-12/mm respectively). Granules surrounding each papula are of similar size to larger granules on plates.

Adambulacral plates bear 4 (occasionally 5) truncate furrow spines which taper towards but are rounded at tip. Proximal spine largest, but all are of similar length. There are 3 truncate, obliquely aligned subambulacral spines, about 1/2 the length of furrow spines. A row of 4 enlarged granules is present behind the subambulacral spines, fig. 1b.

Oral plates bear 8-9 furrow spines, 5 subambulacral spines, 5 enlarged granules and the rest of the plate is covered with granules.

REMARKS: *A. faouzii* differs from *A. bruuni* n. sp. in the arrangement of the primary plates, numerical distribution of the papulae, shape of the furrow spines and the shape and size of the irregularly arranged abactinal plates. This species is distinguished from *A. popei* and *A. wilsoni* n. spp. by the number of inferomarginal plates as compared with the number of superomarginal plates.

A. (Andora) bruuni sp. nov.
Fig. 1d-f

MATERIAL EXAMINED: 1 specimen (holotype): cruise 8, stn 401C RU93, lat. 19°51'S, long. 36°21'E, 62 m, 4.ix.64, 'Anton Bruun'; U.S.N.M. no. E15901, United States National Museum (Smithsonian Institution), Washington, D.C., U.S.A.

DESCRIPTION: The holotype has five arms, R = 54-56.5 mm. r = 9 mm, R/r = 6-6.25. Central-dorsal plate oval, 4 mm × 3.25 mm. Five inner radial plates contiguous with each other and of similar shape and size to and contiguous with central-dorsal. Five interradial plates are oval, maximum diameter (extending into the interradius) = 4.0 mm. Each interradial plate contiguous with inner radial plates on adjacent arms, first carinal (outer radial), first abactinal-lateral row of plates on same adjacent arms and a small plate below the interradial which continues second abactinal-lateral rows across interradial arch. One interradial plate carries madreporite. First carinal (i.e. outer radial) D-shaped, maximum transverse diameter = 3.5 mm. Along abactinal side of each arm is a carinal row of 3-4 plates, each plate = 2 mm (transverse diameter) × 1.75 mm (longitudinal diameter) (except for the larger first carinal plate). There are three abactinal-lateral rows. First 3-4 plates of the carinal and abactinal-lateral rows longitudinally and transversely aligned. Distal to this, plates of carinal and first abactinal row on each side of carinal row become irregularly arranged. These latter are mostly larger than the proximal plates but irregular in size up to 3.5 mm maximum diameter, usually transversely oval or diamond-shaped. Plates of second abactinal-lateral rows extends to arm tip but those of third do not extend beyond 1/3R, fig. 1d.

The 25-26 superomarginal plates are higher than wide, viewed laterally (3 mm × 2.5 mm; fifth plate), but decrease in size regularly distally. The 26-27 inferomarginal plates are slightly smaller than the superomarginals and squarish (2.0 mm × 2.0 mm; fifth plate), fig. 1e-f.

Three rows of actinal plates. First row extends to within 5 mm of arm tip. The plates are of two sizes. Proximally for first 12 inferomarginals plates there are 18 actinal plates, with 2 actinal plates under several of the inferomarginals. Beyond that there are 2 actinal plates for each inferomarginal plate. The actinal plates are irregular in shape but usually becoming squarish distally. Second row comprises 4 plates and the third row 2-3 plates, fig. 1e.

Papulae in groups of up to 10 between abactinal plates, up to 7 between marginal plates and up to 4 between inferomarginal plates and actinal plates. Granules are similar in all respects to those of the previously described species.

Adambulacral plates bear 4, occasionally 5, bevel-tipped furrow spines of which the first spine is largest but all are of similar length; 3-4 truncate or prismatic subambulacral spines, which are about 1/2 length of furrow spines and behind these 4-5 granules only slightly larger then remaining granules covering rest of adambulacral plates, not markedly so, fig. 1e.

Oral plates bear 8-9 furrow spines, 4-5 subambulacral spines, 7-8 enlarged granules and rest of the plate with 3-4 sided granules which are more elongate than those on rest of actinal surface.

REMARKS: *A. bruuni* differs from *A. faouzii* in the more compact arrangement of and size of the primary plates, the shape and size of the abactinal plates on the arms, the numerical distribution of the papulae and the shape of the furrow spines. This species is distinguished from *A. popei* and *A. wilsoni* n. spp. by the arrangement of the marginal plates.

A. (Dorana) wilsoni sp. nov.
Fig. 2a-e

MATERIAL EXAMINED: 1 specimen (holotype); Doc Can Is., Sulu Archipelago, Philippines, 18.3 m, 20.11.64, B. R. Wilson; W.A.M. no. 1054-74, Western Australian Museum, Perth, Western Australia.

1 specimen (juvenile): Pearl Bank, Zal Is., Sulu Archipelago, Philippines, 18.3 m, 21.11.64, B. R. Wilson; W.A.M. no 1757-74, as above.

DESCRIPTION: The holotype has five arms, one of which is damaged, R = 47 mm - 54 mm, r = 8 mm, R/r = 6.1-6.75. Central-dorsal plate oval, slightly lobed, 2.6 mm × 2 mm. Five inner radial plates round to oval, maximum diameter = 2.1 mm. These plates are separated from each other by small plates but are just contiguous with central-dorsal plate. Five interradial plates larger, oval and lobed, maximum diameter (extending into the interradius) = 3.2 mm. These plates are generally separated from inner and outer (first carinal plate) radials by small plates but are contiguous with first plate of first abactinal-lateral row. Outer radial or first carinal plate D-shaped maximum transverse diameter = 2.5 mm. Along abactinal side of each arm a carinal row of 3-4 plates, each plate = 2 mm (transverse diameter) × 1.5 mm (longitudinal diameter) (except for the first carinal plate). There are only two abactinal-lateral rows of which the first extends regularly with the carinal row for 3-4 plates, after which, together with the carinal row the plates become irregularly arranged. Second lateral row extends for about 2/3R. The distal arm plates are

of two sizes with larger, more or less circular plates (up to 2.5 mm diameter) being mixed with small angular plates (up to 1 mm diameter). Plates decrease in size regularly distally. Larger plates stand out because of their slightly convex surface against smaller, flat plates, fig. 2a.

The 22 superomarginal plates are squarish or slightly wider than high (viewed laterally) and are lobed on intermarginal edge (2.5 mm × 2.5 mm; fifth plate). The 31 inferomarginal plates also squarish (1.5 mm × 1.25 mm; seventh plate) with 1.5 plates aligned under each superomarginal, figs 2b-c.

Two actinal rows of plates. First extends to within 5 mm of arm tip, the plates being squarish and aligned two under each inferomarginal. Second row comprises 2-3 plates, fig. 2b.

Papulae in groups of up to 8 between abactinal plates, up to 7 between marginal plates and up to 4 between inferomarginal and actinal plates. Granules are similar to those in preceding species.

Adambulacral plates bear 4-5 bevel-tipped furrow spines, of which first is largest but all are of similar length. There are 3-4 subambulacral spines similarly bevel-tipped, about 1/2 length of furrow spines and closely adpressed against them. The 4-5 granules immediately adjacent to subambulacral spines are barely perceptibly larger than other granules covering the rest of adambulacral plate, fig. 2b.

Oral plates bear 8-9 furrow spines, 5 subambulacral spines and rest of the plate covered with granules similar to those on rest of actinal surface.

The juvenile has five arms, R = 19-20 mm, r = 4 mm, R/r = 4.75-5.0. Primary interradial plates = 1 mm maximum diameter, interradials have long interradial diameter = 1.5 mm, outer radials (first carinals) have transverse diameter = 1.4 mm. Larger, circular distal abactinal plates = up to 1 mm diameter and stand out above smaller, flat plates between. There are two rows of abactinal-lateral plates but the second row cannot be traced beyond first 3-4 plates, fig. 2d.

There are 15 superomarginal and 22-23 inferomarginal plates. Two rows of actinal plates, but second row represented by only one plate. Furrow and subambulacral spines are as in holotype but 1 or 2 rows of 4-5 granules immediately adjacent to subambulacral spines are larger than rest on the plate, fig. 2e.

REMARKS: This species is distinguished from *A. popei* n. sp. by its size, R/r ratio, shape, size and arrangement of the distal abactinal plates, and lobed primary and marginal plates. From *A. faouzii* (Macan) and *A. bruuni* n. sp. it is immediately distinguished by the arrangement of the marginal plates.

A. (Dorana) popei sp. nov.
Fig. 2f-h

MATERIAL EXAMINED: 1 specimen (holotype): Heron Island, Queensland, Australia, 32.4 m, collector unknown (this specimen was brought to my attention by my predecessor, Miss E. C. Pope, who was unable to furnish any further data); A. M. no. J.9653, The Australian Museum, Sydney, New South Wales, Australia.

DESCRIPTION: The holotype has five arms, R = 71.5-84 mm, r = 11 mm, R/r = 6.5-7.6. Central-dorsal plate oval, 2.5 mm × 2.25 mm. Five inner radial plates round, maximum diameter = 2.25 mm. Each is separated from its adjacent neighbour by small plates. Two radials are contiguous with central-dorsal plate. A ring of 15 small plates more or less

encloses plates described above. Five larger, rounded interradial plates, maximum diameter = 3.25 mm, one of which carries the madreporite. These plates are separated from the outer radial (first carinal) plates by a small plate on each side. Interradials in contact with first plate of the first abactinal-lateral row on adjacent arms. A small plate below interradial continues second abactinal-lateral row around the interradial arch. First carinal plate (the outer radial) D-shaped = 3.2 mm (transverse diameter) × 1.75 mm (longitudinal diameter). Along abactinal side of each arm is a carinal row of 3-5 plates, each plate = 3 mm (transverse diameter) × 1.75 mm (longitudinal diameter) (except for the first carinal plate). There are three abactinal-lateral rows. First 3-5 plates of carinal and abactinal-lateral rows regularly transversely and longitudinally aligned. Beyond 5th plate, plates of the carinal and first abactinal-lateral rows are larger than proximal plates and not in regular order. These plates are slightly lobed, irregular in shape but more generally longitudinally oval with maximum diameter up to 3.5 mm. The size of these plates decreases regularly towards tip of arms. Plates of second abactinal-lateral row may be restricted in order to basal 5-6 plates or may be recognisable along length of arms. Third abactinal-lateral row does not extend beyond the proximal half of arms, fig. 2f.

There are 26 superomarginal plates, first two higher than wide (viewed laterally) but rest squarish and decrease in size regularly distally. Fourth superomarginal = 3.5 mm × 3.5 mm. There are 36 inferomarginals similar in shape to superomarginals but smaller, 6th = 2.75 mm × 2.5 mm. First 7 plates more or less underlie first 6-7 superomarginal plates but after that there are 1 or 2 inferomarginals per superomarginal, fig. 2g-h.

Two rows of actinal intermediate plates, first extending to within 10 mm of arm tip and second comprising 2-4 plates. Plates of first row wider than long (2.5 mm × 1 mm) with 2 underlying each inferomarginal. The plates decrease regularly in size distally for about 1/2R but beyond that there is a tendency for the plates to alternate in two sizes. Where arm regeneration has occurred, superomarginals, inferomarginals and actinal-intermediate plates have become misaligned so that superomarginal plates are aligned from inferomarginal line, the inferomarginals from actinal line and actinals form a new line, fig. 2g.

Papulae in groups of twelve abactinally, marginally and actinally. Granules similar in all respects to those described for other species included in this paper.

Adambulacral plates bear 4, occasionally 3, bevel-tipped furrow spines, 3-4 similarly bevel-tipped subambulacral spines which are about half length of furrow spines and closely adpressed to them and 4-5 granules immediately adjacent to subambulacral spines are barely perceptable larger than other granules which cover rest of surface of plates, fig. 2g.

Oral plates bear 8-9 furrow spines, 5 subambulacral spines and rest of surface of plates is covered by angular granules of which 7-10 adjacent to subambulacral spines are slightly the largest.

REMARKS: *A (D.) popei* is most closely related to *A. (D.) wilsoni* n. sp. from which it can be distinguished most readily by its size, R/r ratio, arrangement of the abactinal plates and numerical distribution of the papulae. *A. (D.) popei* is immediately separated from *A. (A.) faouzii* (Macan) and *A. (A.) bruuni* n. sp. by the arrangement of the marginal plates.

DISCUSSION

In his excellent revision of the family Ophidiasteridae, H. L. Clark (1921) laid great stress on the importance of the arrangement of the skeletal plates and the distribution of the papulae in recognising the supra-specific taxa. Using his key, *Andora* can be most closely related to *Nardoa*. The recognition of the subgeneric groups is based on the coincidental occurrence of two distinct species with equal numbers of inferomarginal and superomarginal plates in the Indian Ocean and two distinct species with substantially more inferomarginal than superomarginal plates in the Pacific Ocean. Since all the other features, although specific, are similar in the four species, the species are retained under the mantle of a common generic taxon. The species so far encountered extend to depths of 13.5 m (Arabian Sea) and 62 m (Mozambique Channel) in the Indian Ocean and to 18.3 m (Philippines) and 32.4 m (Heron Island) in the Pacific. The genus can thus be considered to inhabit relatively shallow water. Ecological data available indicates that the species prefer hard substrates since Macan (1938) records that off the Arabian Coast the slopes are steep and rocky and Wilson records the larger specimen from the Philippines as being collected from rocky/*Lithothamnion* bottom (holotype of *wilsoni*) and the smaller one from a sandy/*Lithothamnion* bottom (juvenile of *wilsoni*). Of the related genera, *Nardoa* is commonly collected intertidally or at the most to a few meters, *Certonardoa* is collected from similar depths and *Heteronardoa* from deeper water.

ACKNOWLEDGEMENTS

I am indebted to Miss A. M. Clark (British Museum (Natural History), London); Mrs L. M. Marsh (Western Australian Museum, Perth); Dr F. Hotchkiss (State University of New York, U.S.A. (formerly at Smithsonian Institution, Washington, D.C.)) for sending me material for examination. I thank Miss E. Pope (Sydney) for bringing the specimen of *A. (D.) popei* to my attention. Mr G. Millen is thanked for photographing the specimens described in this paper.

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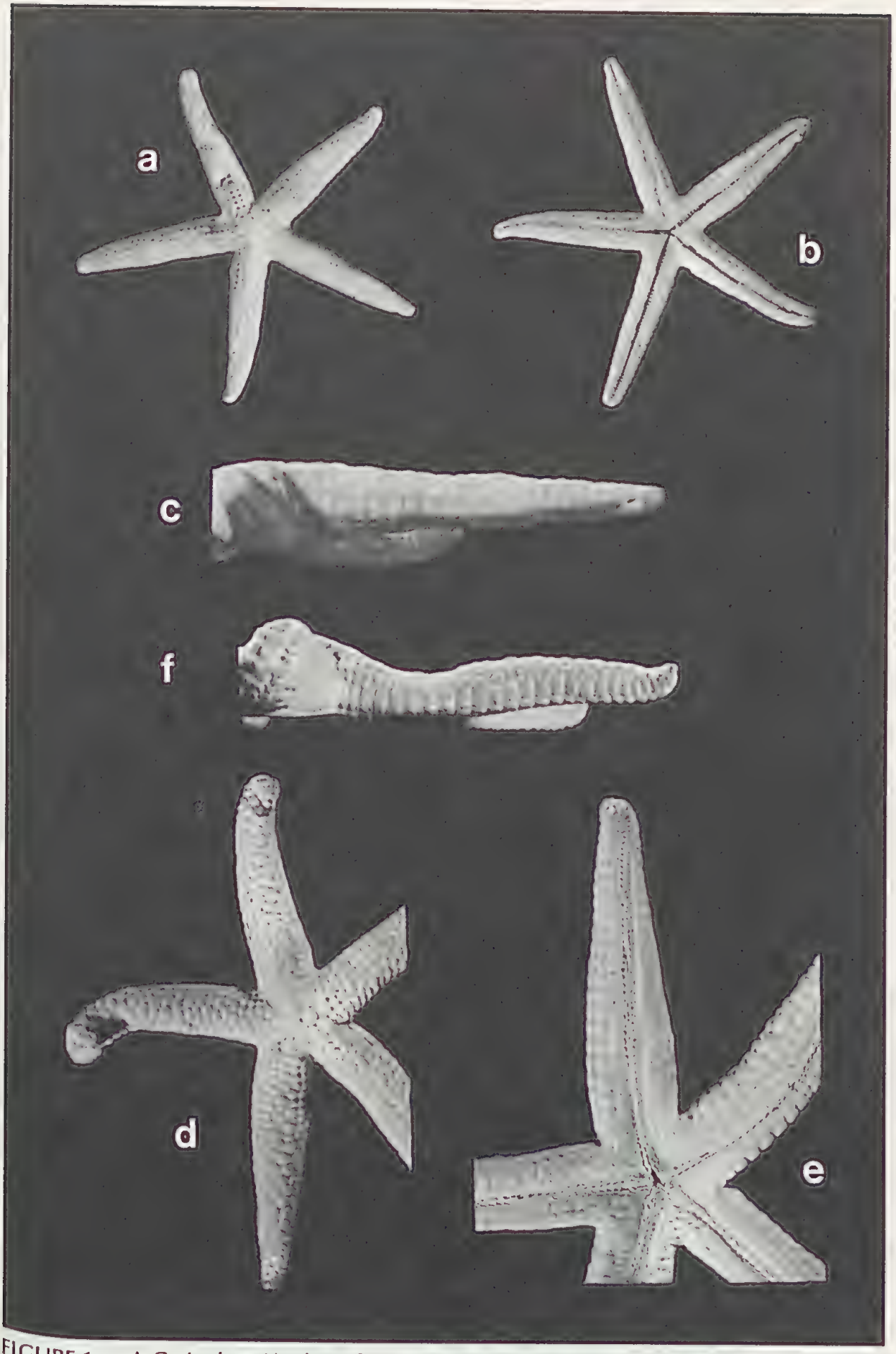

FIGURE 1.— A-C. *Andora (Andora) faouzii* (Macan), holotype, a. abactinal, b. actinal, c. lateral views, R = 48.5 — 54mm. D-F. *A. (A.) bruuni* sp. nov., holotype, d. abactinal, e. actinal, f. lateral views, R = 54 — 56.5mm.

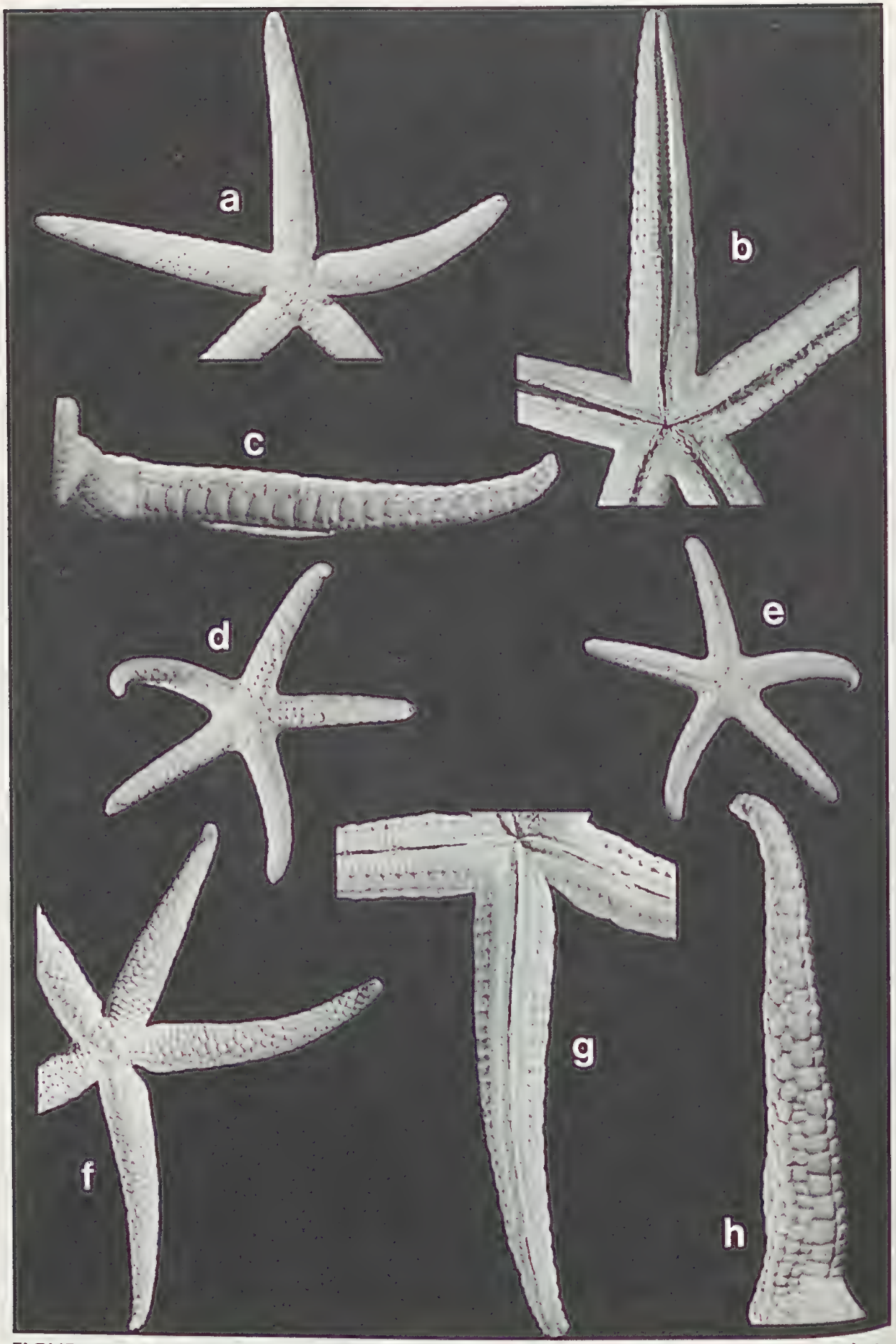

FIGURE 2. — A-C. *Andora (Dorana) wilsoni* sp. nov., holotype, a. abactinal, b. actinal, c. lateral views, R = 47 — 54mm. D-E. *A. (D.) wilsoni* sp. nov., juvenile, d. abactinal, e. actinal views, R = 19 — 20mm. F-H. *A. (D.) popei* sp. nov., holotype, f. abactinal, g. actinal, h. lateral views, R = 71.5 — 84.

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RECORDS OF THE AUSTRALIAN MUSEUM

PSOCOPTERA OF MUOGAMARRA NATURE RESERVE

C. N. SMITHERS

NEPHTYIDAE (POLYCHAETA)

S. RAINER AND P. A. HUTCHINGS

REVISION OF THE DAMSELFISH *DASCYLLUS*

H. A. RANDALL AND G. R. ALLEN

OF VICTO

VOLUME 31 NUMBERS 7-9 DECEMBER 1977 $4

THE PSOCOPTERA OF MUOGAMARRA NATURE RESERVE

by C. N. SMITHERS

The Australian Museum, Sydney

NATIONAL MUSEUM
16 JAN 1978
OF VICTORIA

SUMMARY

In a preliminary study Psocoptera were periodically collected from eight habitats in Muogamarra Nature Reserve, near Sydney. Forty-three species were taken of which fifteen are described as new. Rainforest and *Casuarina* habitats yielded the greatest variety of species. Populations were highest in summer on *Casuarina* and showed little seasonal variation in rainforest; dry sclerophyll habitats, on the other hand, yielded greater populations in winter than summer. In each habitat one or two species were dominant. *Acacia floribunda* and *Eucalyptus* spp. were poorest in species and specimens.

INTRODUCTION

During the latter part of 1973 and through most of 1974 collections of Psocoptera were made at intervals from selected habitats in Muogamarra Nature Reserve. Psocoptera had not previously been recorded from the Reserve. The object of the work was to ascertain which species were present and to obtain some indication of any gross habitat preferences or seasonal fluctuations in numbers, if any, as a basis for planning future, more detailed, biological and ecological work. The basic information necessary for rational planning of such work has not been available for Australian species and very little appropriate work which might be applicable to Australian conditions has been done elsewhere.

This paper presents the results of a preliminary survey.

MUOGAMARRA NATURE RESERVE

Muogamarra Nature Reserve is an area of broken Hawkesbury sandstone country covering about 2,300 hectares situated near Cowan, 38 kilometres north of Sydney. It is bounded on the east by the Pacific Highway and on the west by the irregular shores of Berowra Water, a tributary of the Hawkesbury River.

In the north, the curving Hawkesbury River itself forms the boundary and in the south, residential areas adjoin the border of the Reserve.

Most of the Reserve carries vegetation cover of dry sclerophyll forest with some heathlike areas on flatter hilltops. The vegetation of the area has been described by Pidgeon (1938).

In altitude the land rises from virtually sea level to almost 200 metres.

Records of the Australian Museum, 1977 **Vol. 31 No. 7,** 251-306, Figures 1-98.

LIST OF SPECIES OF PSOCOPTERA FROM MUOGAMARRA NATURE RESERVE

The following species have been taken from Muogamarra Nature Reserve during the present survey.

LEPIDOPSOCIDAE

Echmepteryx (Loxopholia) brunnea Smithers
Echmepteryx (Thylacopsis) picta sp.n.

CAECILIIDAE

Caecilius macrostigma Enderlein
Caecilius lineatus sp.n.
Caecilius pteridii sp.n.
Paracaecilius hylobius sp.n.
Enderleinella globiclypeus (Enderlein) comb. nov.
?Caeciliid gen. et sp.n.

STENOPSOCIDAE

Taeniostigma trickettae Smithers

ECTOPSOCIDAE

Ectopsocus californicus (Banks)
Ectopsocus punctatus Thornton and Wong
Ectopsocus perplexus sp.n.
Ectopsocus pteridii sp.n.
Ectopsocus parmatus sp.n.
Ectopsocus russulus sp.n.
Ectopsocus albiceps sp.n.

PERIPSOCIDAE

Peripsocus milleri (Tillyard)
Peripsocus maoricus (Tillyard)
Peripsocus tillyardi New
Peripsocus hamiltonae sp.n.
Peripsocus roseus sp.n.

PSEUDOCAECILIIDAE

Pseudocaecilius lachlani Enderlein
Heterocaecilius brunellus (Tillyard)
Lobocaecilius monicus Lee and Thornton
Pseudoscottiella tanei sp.n.

PHILOTARSIDAE

Aaroniella rawlingsi Smithers
Austropsocus viridis (Enderlein)
Austropsocus tibialis Thornton and New

Haplophallus ornatus Thornton and New
Haplophallus sinus Thornton and New
Haplophallus guttatus (Tillyard)

ELIPSOCIDAE

Spilopsocus ruidis Smithers
Paedomorpha gayi Smithers

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OF VICTORIA

PSOCIDAE

Blaste tillyardi Smithers
Blaste taylori New
Blaste (Lasiopsocus) michaelseni (Enderlein)
Copostigma (Clematostigma) latimentula sp.n.
Copostigma (Clematostigma) paula sp.n.
Ptycta muogamarra sp.n.
Sigmatoneura formosa (Banks)
Trichadenotecnum enderleini (Roesler)

MYOPSOCIDAE

Phlotodes australis (Brauer)
Phlotodes furcatus (Smithers)

DESCRIPTIONS OF NEW SPECIES AND RECORDS OF PSOCOPTERA FROM MUOGAMARRA NATURE RESERVE

In the lists of material examined given below, collectors are indicated by initials as follows: C. N. Smithers (C.N.S.), Aletta S. Smithers (A.S.S.), Graeme F. Smithers (G.F.S.), Hartley G. Smithers (H.G.S.) and Robyn D. Brewer (R.D.B.).

Material is desposited in the Australian Museum (AM) and the Australian National Insect Collection (ANIC).

In the descriptions the following abbreviations are used: F (femur); T (tibia); t_1, t_2, t_3 (first, second and third tarsal segments); rt (ratio of tarsal segment lengths); ct (number of ctenidiobothria on tarsal segments); f_1, f_2 (lengths of first and second flagellar segments); IO/D and PO (eye measurement ratios) are measured using the method of Badonnel, i.e. IO = distance across vertex between the eyes, D = eye diameter from front to back as seen from above, P = transverse width of eye seen from above (see Ball, 1943).

LEPIDOPSOCIDAE

Echmepteryx (Loxopholia) brunnea Smithers

Echmepteryx (Loxopholia) brunnea Smithers 1965. *J. ent. Soc. Qd* 4:75, figs. 11-16.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 2♀, I.xi. 1973 (C.N.S.); 1♀, 29.xi.1973 (C.N.S., G.F.S.); 1♀, 28.ii.1974 (C.N.S., A.S.S.); 1♀, 1♂, 22.iii.1974 (C.N.S., A.S.S.); 1♂, 23.v.1974 (C.N.S.); 1 nymph, 9.vii.1974 (C.N.S., R.D.B.); 1♂, 1 nymph, 18.vii.1974 (C.N.S., A.S.S.); 1♀, 1 nymph, 18.vii.1974 (C.N.S., A.S.S.); 1♀, 1 nymph, 19.ix.1974 (C.N.S.); 1♂, 1 nymph, 23.viii.1974 (C.N.S., A.S.S.) (AM).

Echmepteryx (Thylacopsis) picta sp. n.

MALE

COLORATION: (in alcohol). Head pale buff with a distinct brown pattern (fig. 1). Median epicranial suture dark brown, anterior arms pale brown. Labrum black in distal half, white in proximal half, the white area divided by a median black stripe running from the base of the labrum to the black distal area. Genae pale buff with a brown posterior, longitudinal patch which runs from just below the compound eye to the base of the mandible; a brown mark runs from compound eye to join the brown circle surrounding antenna base. Antennae brown. Eyes grey with brown markings. Ocelli each with a black pigmented area on the side nearest the junction of the median and anterior arms of the epicranial suture. Maxillary palps brown with the apex of the second and third segments white. Mesonotum brown. Legs all similarly coloured; femora pale brown on external face, becoming a little darker near distal end. Tibiae pale with two dark brown bands of width equal to the intervening paler parts of the tibiae; basal tarsal segment dark brown basally, pale in distal half, second and third segments brown. Fore wing membrane (fig. 2) grey with some hyaline, colourless areas. Veins various shades of grey-brown depending on development. Hind wing (fig. 3) hyaline, veins brown; abdomen pale with irregular, segmentally arranged, brown marks dorsally and lateroventrally.

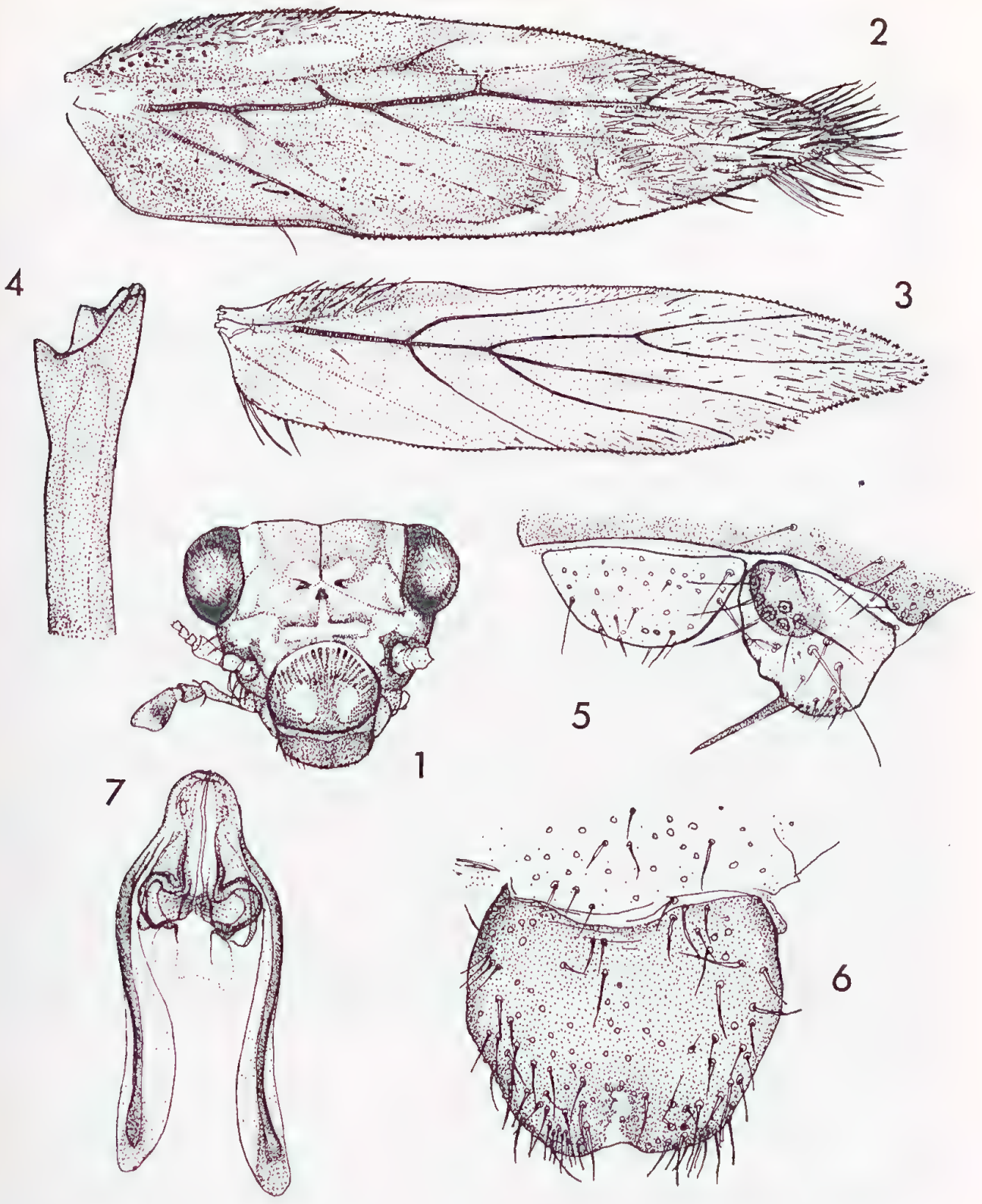
MORPHOLOGY: Length of body: 2.5 mm. Epicranial suture very distinct. Vertex fairly sharp, head flattened with postclypeus only slightly bulbous. Vertex with strongly developed setae, similar setae scattered over rest of head with a denser grouping between compound eye and antenna base. Antennae with at least 38 segments and at least 2.2 mm long. Lacinia (fig. 4). Measurements of hind leg: F: 0.70 mm; T: 1.15 mm t_1: 0.69 mm; t_2: 0.11 mm; t_3: 0.08 mm; rt: 6.3:1:0.73; fore wing length: 2.5 mm; fore wing width 0.72 mm. Fore wings almost parallel-sided for basal three-quarters, the anterior and posterior margins converging in distal quarter to the pointed apex. Veins poorly developed except for M + Cu_1, M, Rs + M and Rs which are more strongly developed. This gives the appearance of a well-developed, median, longitudinal supporting vein in the basal half of the wing. Fore wing clothed with mostly asymmetrical scales interspersed with well developed setae, the marginal setae near the wing apex bearing small sharp points along one side. Hind wing length: 2.24 mm; hind wing width: 0.52 mm. Hind wing (fig. 3) with margins converging to pointed apex in distal third. In left wing of holotype M_1 and M_2 arise independently, in right wing they arise from a very short common stem. Veins, except Sc, Cu_2 and IA well developed. Epiproct (fig. 5) lightly sclerotized, setose. Paraproct (fig. 5) a little more heavily sclerotized than epiproct and bearing six setae with rosette bases in addition to other scattered setae. Hypandrium (fig. 6) with posterior median emargination. Phallosome (fig. 7).

FEMALE: — Unknown.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♂ (holotype), 18.vii.1974 (C.N.S., A.S.S.). (AM).

Holotype in the Australian Museum.

DISCUSSION: *Echmepteryx (Thylacopsis) picta* differs from *E. (T.) madagascariensis* (Kolbe) and *E. (T.) pallida* Smithers, the other Australian members of the subgenus *Thylacopsis* Enderlein, in its distinctive facial pattern. In *E. (T.) pallida* the head is pale with a sinuous, reddish brown band across the front of the head and in *E. (T.) madagascariensis* the head is pale with darker labrum and postclypeus.



FIGURES 1-7. — *Echmepteryx (Thylacopsis) picta* sp. n. 1.♂ head, 2.♂ forewing, 3.♂ hindwing, 4.♂ lacinia, 5.♂ epiproct and paraproct, 6.♂ hypandrium, 7.♂ phallosome.

CAECILIIDAE

Caecilius macrostigma Enderlein

Caecilius macrostigma Enderlein 1903. *Ann. hist. –nat. Mus. hung.* 1:272, pl. VII, fig. 37.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♀, 18.x.1973 (C.N.S., A.S.S.); 2 nymphs, 1.xi.1973 (C.N.S.); 1 nymph, 13.xii.1973 (C.N.S., A.S.S.); 1 ♂, 30.i.1974 (C.N.S., A.S.S.) (AM).

Caecilius lineatus sp. n.

FEMALE

COLORATION: (in alcohol). Head (fig. 8) pale brownish yellow with a brown rectangular patch on the frons between ocellar triangle and epistomial suture and a circular paler brown patch on the median epicranial suture about half way between ocellar tubercle and occipital region. In well pigmented specimens there is a faint suggestion of a median brown band through the postclypeus. Labrum and postclypeus a little paler than rest of head. Antennae with scape, pedicel and first two flagellar segments brown, more distal segments darker. Eyes black. Ocellar tubercle pale, ocelli black. Maxillary palps pale brownish yellow, the distal third of apical segment pale brown. Mesothoracic antedorsum brown with a pale median area; lateral lobes mostly brown with area adjacent to sutures pale. Fore wings (fig. 9) transparent, tinged with pale brown in posterior part of wing, very pale in cell R, basal part of cell R_1, costal cell and pterostigma. Cell IA brown. Veins brown except for R, Rs before Rs-M confluence and R_1 (hind margin of pterostigma) which are almost colourless; Cu_{1b} evanescent. Hind wing hyaline; veins pale brown. Legs pale brownish yellow except for slightly darker second tarsal segment and dark brown claws. Abdomen pale creamy yellow.

MORPHOLOGY: Length of body: 3.0 mm. Median epicranial suture very distinct, anterior arms less so but obvious, curved. Postclypeus very bulbous and prominent. Labrum with strongly developed antero-lateral styli. Lengths of flagellar segments: f_1: 0.62 mm; f_2: 0.47 mm; first flagellar segment not thickened, almost straight. Eyes fairly large, not reaching level of vertex. IO/D (Badonnel): 1.77; PO: 0.77. Ocelli small. Lacinia (fig. 10). Tibiae of uniform width. Mesothorax without precoxal suture. Measurements of hind legs: F: 0.5 mm; T: 0.87 mm; t_1: 0.2 mm; t_2: 0.12 mm; rt: 1.6:1; ct: 18, 0. Fore wing length: 3.4 mm; fore wing width 1.0 mm. Fore wings fairly elongate and narrow, length about 3.4 times width. Venation as illustrated (fig. 9). Cu_2 without setae. Hind wing length: 2.7 mm; hind wing width: 0.75 mm; length: width: 3.6:1. Epiproct and paraproct (fig. 11). Subgenital plate simple, setose. Gonapophyses (fig. 12). Glandular part of spermathecal duct fairly long.

MALE

COLORATION: (in alcohol). Head (fig. 13) as in female but the epicranial brown patch is usually not evident or only slightly so.

MORPHOLOGY: Length of body: 2.3 mm. Length of flagellar segments: f_1: 0.60 mm; f_2: 0.40 mm. Antennae thicker than in female. Eyes large, much larger than in female and reaching well above level of vertex. IO/D (Badonnel): 0.64; PO: 0.73. Ocelli larger than in female. Lacinia similar to that of female. Tibiae a little broader near tarsi but no sign of expansion along length. Measurements of hind leg: F: 0.52 mm; T: 0.94 mm; t_1: 0.25 mm; t_2: 0.14 mm; rt: 1.8:1, ct: 18, 0. Fore wing length: 3.2 mm; fore wing width: 1.1 mm. Fore wings similar to those of female but relatively a little broader. Hind wing

length: 2.6 mm; hind wing width: 0.75 mm. Epiproct and paraproct without papillar fields. Setae on hypandrium somewhat concentrated in areas on each side leaving the median part of the hind margin relatively free of setae. Phallosome (fig. 14).

MATERIAL EXAMINED: Muogammarra Nature Reserve, N.S.W. 1♀ (holotype), 1♂ (allotype), 20.vi.1974 (C.N.S., A.S.S.). Paratypes: 2♀, 18.x.1973 (C.N.S., A.S.S.); 1♂, 3♀, 1.xi.1973 (C.N.S.); 4♂, 12♀, 15.xi.1973 (C.N.S., A.S.S.); 1♂, 2♀, 29.xi.1973 (C.N.S., G.F.S.); 1♂, 2♀, 13.xii.1973 (C.N.S., A.S.S.); 5♂, 2♀, 16.i.1974 (C.N.S., H.G.S.); 1♀, 30.i.1974 (.C.N.S., A.S.S.); 4♂, 28.ii.1974 (C.N.S., A.S.S.); 2♀, 22.iii.1974 (C.N.S., A.S.S.), 2♀, 4.iv.1974 (C.N.S., A.S.S.); 1♂, 2.v.1974 (C.N.S., A.S.S.); 1♂, 2♀, 20.vi.1974 (C.N.S., A.S.S.); 1♂, 18.vii.1974 (C.N.S., A.S.S.); 1♀, 19.ix.1974 (C.N.S.); 1♀, 3.x.1974 (C.N.S.); 1♀, 22.x.1974 (C.N.S.) (AM); 1♂, 2♀, 7.xi.1974 (C.N.S.) (ANIC).

Holotype and allotype in the Australian Museum; paratypes in the Australian Museum and the Australian National Insect Collection.

DISCUSSION: For comparison with other Australian species of *Caecilius Curtis* see key (p.259). Wing lengths of paratypes: ♂♂ : 3.2, 3.1, 2.9, 3.1 mm; ♀♀ : 3.4, 3.3, 3.1, 3.0 mm.

Caecilius pteridii sp.n.

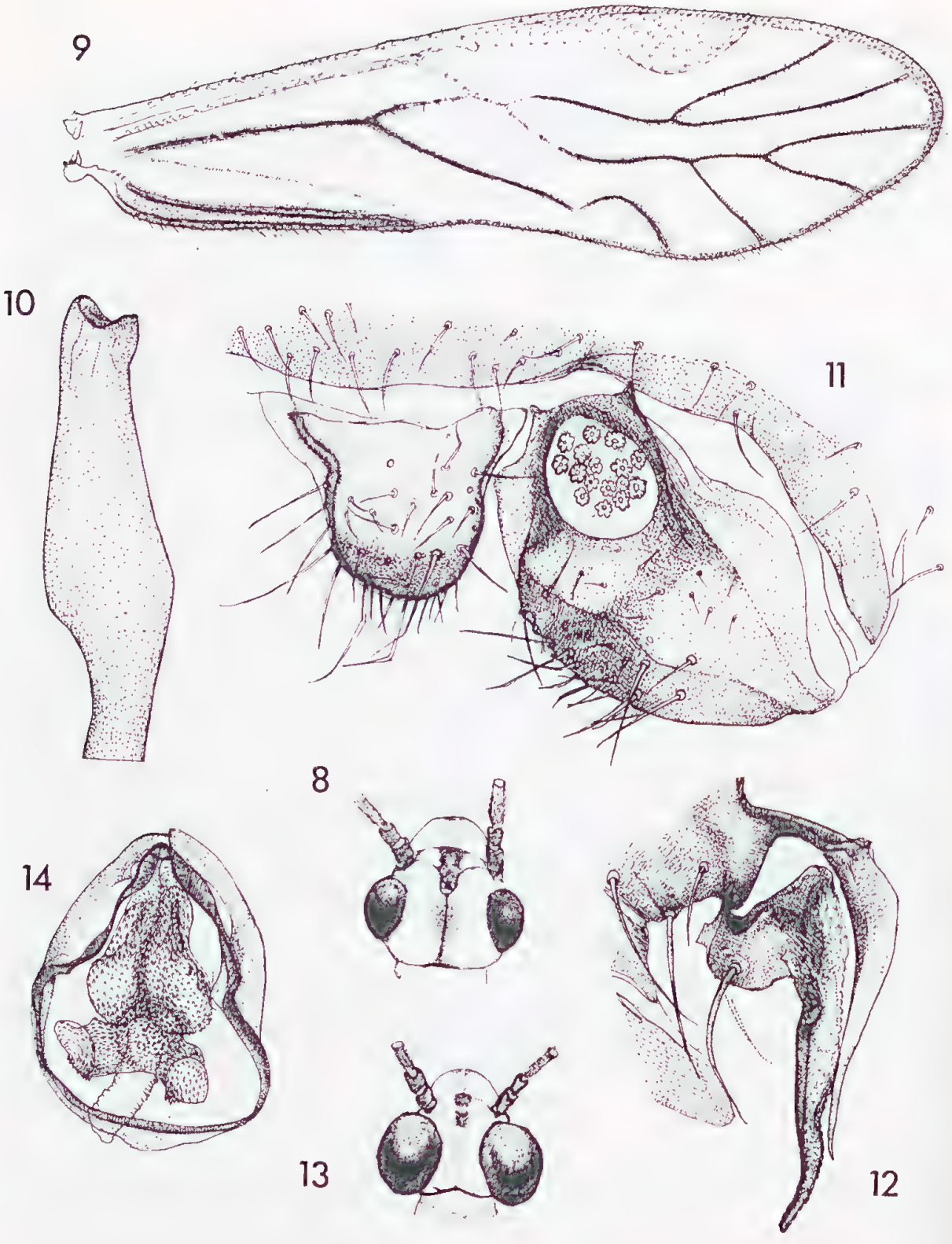
FEMALE

COLORATION: (in alcohol). Head (fig. 15) pale brownish yellow with a brown triangular mark anterior to ocellar triangle, a brown mark on either side of the median epicranial suture from ocellar triangle to back of head, a very dark brown spot behind each eye, between antenna base and eye and a very dark brown mark extending from the latter to the epistomial suture but not meeting the mark from the other side. Postclypeus a little darker than vertex. Labrum pale, a dark spot at anterior lateral corner. Neck and prothorax coloured as head with a lateral brown stripe. Antennae pale brown. Meso- and metanota pale brownish yellow, brown on each side of antedorsum and on each lateral lobe. Fore wing (fig. 16) almost uniformly tinged with very pale brown, cell IA darker, veins and pterostigma pale brown. Membrane bordering veins narrowly colourless. Hind wing faintly tinged with brown; veins pale. Legs pale brownish yellow; second tarsal segment little darker than first. Abdomen pale.

MORPHOLOGY: Length of body: 2.3 mm. Median epicranial suture distinct; anterior arms faint. Postclypeus strongly bulbous. Lengths of antennal segments: f_1 : 0.39 mm.; f_2 : 0.29 mm. Eyes fairly small. IO/D (Badonnel): 1.4, PO : 0.70. Ocelli small. Lacinia (fig. 17). Labrum without antero-lateral styli. Tibiae of uniform width, ctenidia and setae fewer towards basal end of tibia. Measurements of hind leg: F : 0.49 mm.; T : 0.84 mm.; t_1 : 0.27 mm.; t_2 : 0.13 mm.; rt : 2:1.; ct : 18, 0. Fore wing length: 2.5 mm.; fore wing width: 0.8 mm. Fore wing with fairly low areola postica, radial fork well basad of origin of M_3. Cu_2 without setae. Hind wing length: 1.9 mm.; hind wing width: 0.6 mm. Cu_2 in hind wing very pale and fine. Epiproct simple, rhomboidal, setose (fig. 18). Paraproct without papillar area and with ovoid trichobothrial field of 12 setae with rosette bases (fig. 18). Subgenital plate with strong lateral apophyses. Glandular part of spermathecal duct fairly long. Gonapophyses (fig. 19).

MALE

COLORATION: (in alcohol). Head (fig. 20) as in female but vertex lacking the darker areas on either side of the median epicranial suture. Antennae brown, a little darker than in female.



FIGURES 8-14. — *Caecilius lineatus* sp. n. 8.♀ head, 9.♀ forewing, 10.♀ lacinia 11.♀ epiproct and paraproct, 12.♀ gonapophyses, 13.♂ head, 14.♂ phallosome.

MORPHOLOGY: Length of body: 2.1 mm. Median epicranial suture distinct but less so than in female owing to paler colour. Antennae a little thicker than in female. Lengths of flagellar segments: f_1 : 0.48 mm.; f_2 : 0.40 mm. Eyes large, much larger than in female, reaching above level of vertex. IO/D (Badonnel): 0.60.; PO : 0.77. Labrum and lacinia as in female. Tibiae of fore and middle legs very slightly swollen in basal part on which ctenidia and seta are poorly developed. Measurements of hind leg: F : 0.56 mm.; T : 1.04 mm.; t_1 : 0.31 mm.; t_2 : 0.13 mm.; rt : 2.4:1.; ct : 20, 0. Fore wing length: 2.8 mm.; fore wing width: 1.0 mm.; venation and setae as in female. Hind wing length: 2.0 mm.; hind wing width: 0.65 mm. Cu_2 indistinct. Epiproct (fig. 22) without papillae; paraproct (fig. 21) with an area bearing well developed papillae. Hypandrium with middle of hind margin relatively clear of setae. Phallosome (fig. 23); spatulate apex of external parameres without pores.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♀ (holotype), 1 ♂ (allotype), 23.v.1973 (C.N.S.). Paratypes: 1 ♂, 1 ♀, 15.xi.1973 (C.N.S., A.S.S.); 1 ♀, 29.xi.1973 (C.N.S., G.F.S.); 1 ♂, 23.xii.1973 (C.N.S., A.S.S.); 2 ♀, 18.iv.1974 (C.N.S.); 1 ♂, 2.v.1974 (C.N.S., A.S.S.); 1 ♂, 1 ♀, 19.ix.1974 (C.N.S.); 1 ♂, 3.x.1974 (C.N.S.); 1 ♀, 22.x.1974 (C.N.S.) (AM); 1 ♂, 1 ♀, 7.xi.1974 (C.N.S.) (ANIC).

Holotype and allotype in the Australian Museum; paratypes in the Australian Museum and the Australian National Insect Collection.

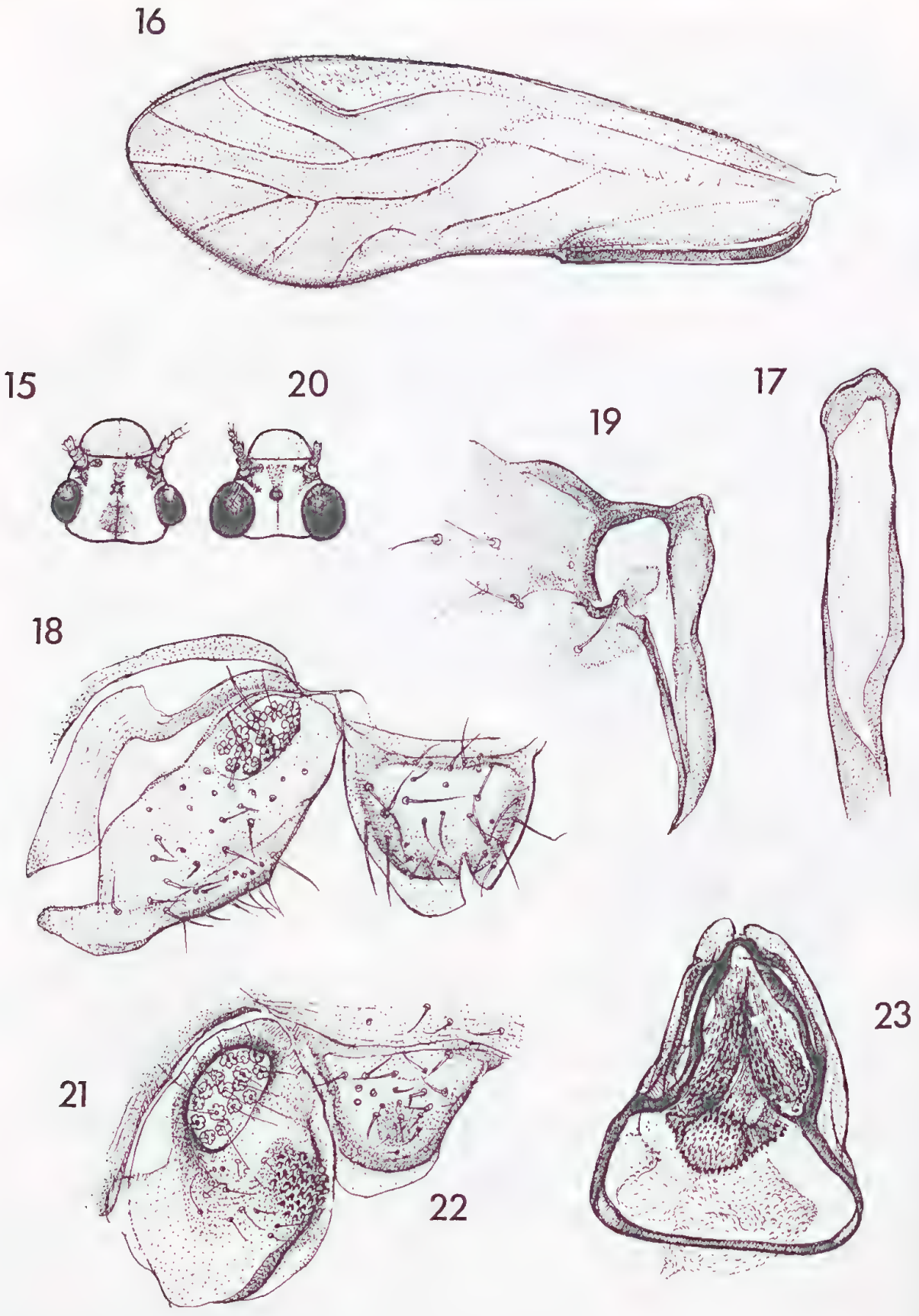
DISCUSSION: For comparison with other Australian species of *Caecilius* see key (p.259). Wing length of paratypes: ♀♀: 2.4, 2.4, 2.5 mm; ♂♂: 2.5, 2.3, 2.4 mm.

Caecilius is a large, worldwide, genus of at least 250 species of which only eight have so far been recorded from Australia although many more are present in collections. Badonnel (1955) grouped species on the basis of easily discernible characters into a series of groups and subgroups without implying relationships.

Mockford (1965, 1966, 1969) is in the process of regrouping the species using a range of morphological features which, it is hoped, will provide a better indication of relationships. This work is incomplete, however, and it would be unwise to attempt to fit the known Australian species into Mockford's system at present. For the present, therefore, key characters for distinguishing the Australian species only are given in a dichotomous key for all the known Australian species.

KEY TO AUSTRALIAN SPECIES OF *CAECILIUS* CURTIS

1. Fore wing pale, yellowish, sometimes cell IA darker than rest of membrane .. 2
   Fore wing with blotched or clearcut pattern 5
2. Cell IA darker than rest of membrane 3
   Cell IA not darker than rest of membrane ..... *australis* Enderlein
3. A brown mark behind antenna base 4
   No brown mark behind antenna base ..... *lineatus* sp.n.
4. A dark mark between eye and epistomial suture ..... *pteridii* sp.n.
   No dark mark between eye and epistomial suture ..... *quercus* Edwards
5. Fore wing pattern consisting of a longitudinal, irregular, median band 6
   Fore wing irregularly blotched with various shades of brown (pterostigma with strongly developed posterior angle) 7



FIGURES 15-23. — *Caecilius pteridii* sp. n. 15. ♀ head, 16. ♀ forewing, 17. ♀ lacinia, 18. ♀ epiproct and paraproct, 19. ♀ gonapophyses, 20. ♂ head, 21. ♂ epiproct, 22. ♂ paraproct, 23. ♂ phallosome.

6. Dark median band of fore wing extending well into median cells with extension of colour along branches of media ..... *flavicosta* Banks
   Dark median band of fore wing not extending along branches of media ..... *morosus* Banks

7. ♂IO/D : 0.90; PO : 1.0; ♀ ,IO/D : 2.3; PO : 0.86 ..... *semifuscatus* (Tillyard)
   ♂IO/D : 1.1; PO : 0.83; ♀ , IO/D : 2.2; PO : 1.7 ..... *macrostigma* Enderlein

Paracaecilius hylobius sp.n.

FEMALE

COLORATION: (in alcohol). A pale yellowish species with faint suggestion of a brown area across vertex and two broad brownïsh bands along dorsum of thorax. Antennae pale, slightly brownish from second flagellar segment. Eyes black. Ocellar tubercle pale with ocellar pigment reddish brown. Legs uniformly coloured as body. Fore wings (fig. 24) hyaline with faint suggestion of brown in membrane in distal half; cell IA pale brown. Veins colourless in basal half of wing, very pale brown in darker parts of distal half of wing.

MORPHOLOGY: Length of body: 2.0 mm. Median epicranial suture distinct, anterior arms poorly developed. Postclypeus bulbous. Labrum with strongly sclerotized inwardly curving lateral marginal rods (fig. 25). Lengths of flagellar segments: f_1 : 0.44 mm.; f_2 : 0.39 mm. First flagellar segment slightly curved. Eyes fairly large. IO/D (Badonnel): 1.1; PO : 0.75. Lacinia (fig. 26) with very narrow bifid apex. Mesothoracic precoxal suture present ventrally, evanescent dorsally. Tibiae without any suggestion of thickening. Measurements of hind leg: F: 0.49 mm.; T : 0.89 mm.; t_1 : 0.28 mm.; t_2 : 0.08 mm.; rt : 3.4:1.; ct : 19, 0. Femora fairly narrow. Fore wing length: 2.6 mm.; fore wing width: 0.9 mm. Fore wings fairly broad (fig. 24). Pterostigma with broadening but smoothly rounded hind margin. Subcosta evanescent, remnant straight. Stem of Rs before junction with M strongly curved, after separation from M slightly sinuous and shorter than R_{4+5}.Areola postica small. Veins setose except IA. Epiproct (fig. 27) and paraproct (fig. 27); setae with well-developed alveoli; tubercles absent. Subgenital plate with long, fine setae. Glandular part of spermathecal duct short, in two sections, the distal one of even width, the smaller proximal section narrowing towards the bulb of the spermatheca. Gonapophyses (fig. 28) of characteristic form, the dorsal valve broad basally, tapering distally with a dorsally sclerotized margin, otherwise membranous. No clear basal connection to ninth tergite.

MALE

COLORATION: (in alcohol). As female but without any indication of darkening on vertex but dorsal stripes on thorax a little darker.

MORPHOLOGY: Length of body: 2.2 mm. Epicranial suture indistinct. Lengths of flagellar segments: f_1 : 0.602 mm.; f_2 : 0.504 mm. Antennae hardly thicker than in female. Eyes very large, reaching above level of vertex, almost circular seen from above. IO/D : 0.36; PO : 0.91. Labrum and lacinia as in female. Tibiae not thickened, femora long and narrow. Measurements of hind leg: F : 0.56 mm.; T : 1.10 mm.; t_1 : 0.38 mm.; t_2 : 0.10 mm.; rt : 3.8:1; ct : 24, 0. Fore wing length: 3.2 mm.; fore wing width: 1.1 mm.; venation as in female. Hind wing length: 2.1 mm.; hind wing width: 0.7 mm. Epiproct (fig. 29). Paraproct (fig. 29). Phallosome (fig. 30) with very broad external parameres.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♀ (holotype) 13.xii.1973 (C.N.S., A.S.S.); 1 ♂ (allotype), 23.v.1974 (C.N.S.). Paratypes 2 ♀ , 15.xi.1973 (C.N.S., A.S.S.); 1 ♀ , 29.xi.1973 (C.N.S., G.F.S.); 1 ♀ , 4.iv.1974 (C.N.S., A.S.S.); 1 ♀ , 7.xi.1974 (C.N.S.) (AM).

Holotype, allotype and paratypes in Australian Museum.

DISCUSSION: The genus *Paracaecilius* Badonnel has been recorded only from Africa and Madagascar; seven species are included, a key to six of which is given by Badonnel (1967). Later Badonnel, (1969) added the seventh *(P. wittei* (Bad.)). In the key given by Badonnel *P. hylobius* runs to *P. cyanops* Badonnel, but differs from that species in having paler wings and larger eyes. In *P. cyanops* IO/D = 0.83. From *P. wittei* (Badonnel) it differs in lacking a bold wing pattern. Wing length of paratypes: ♂ : 3.2 mm; ♀♀ : 2.6, 2:9, 2.8 mm.

Paracaecilius hylobius is the first species of the genus to be recorded from Australia.

Enderleinella globiclypeus (Enderlein) comb. nov.

Caecilius globiclypeus Enderlein 1903. *Ann. hist.-nat. Mus. hung* 1:275.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♀ , 1.xi.1973 (C.N.S.); 1 ♂, 1 ♀ , 15.xi.1973 (C.N.S., A.S.S.) (AM).

DISCUSSION: Enderlein (1903) described *Caecilius globiclypeus* but gave no information on female genitalia nor mouthparts.

The specimens from Muogamarra Nature Reserve agree well with Enderlein's description in colour and morphological features, e.g., excessively enlarged postclypeus, narrow pterostigma, short radial fork. These are features characteristic of species of *Enderleinella* Badonnel and dissection of the female from Muogamarra discloses that the gonapophyses were also of the broad membranous form characteristic of *Enderleinella* and not of the sclerotized, acuminate form found in *Caecilius*. *Caecilius globiclypeus* Enderlein should be placed in *Enderleinella*. The genus *Enderleinella* has been recorded so far from Europe and New Zealand, with one species from each area.

?Caeciliid gen. et. sp. n.

In addition to the identifiable caeciliid material one female was taken in which the genitalia are of peculiar form. The specimen undoubtedly represents an interesting undescribed genus but as only one specimen was taken and the genitalia preparations are unsatisfactory it is considered unwise to describe the species until more material is available. Repeated efforts to obtain more specimens from the same locality have so far failed.

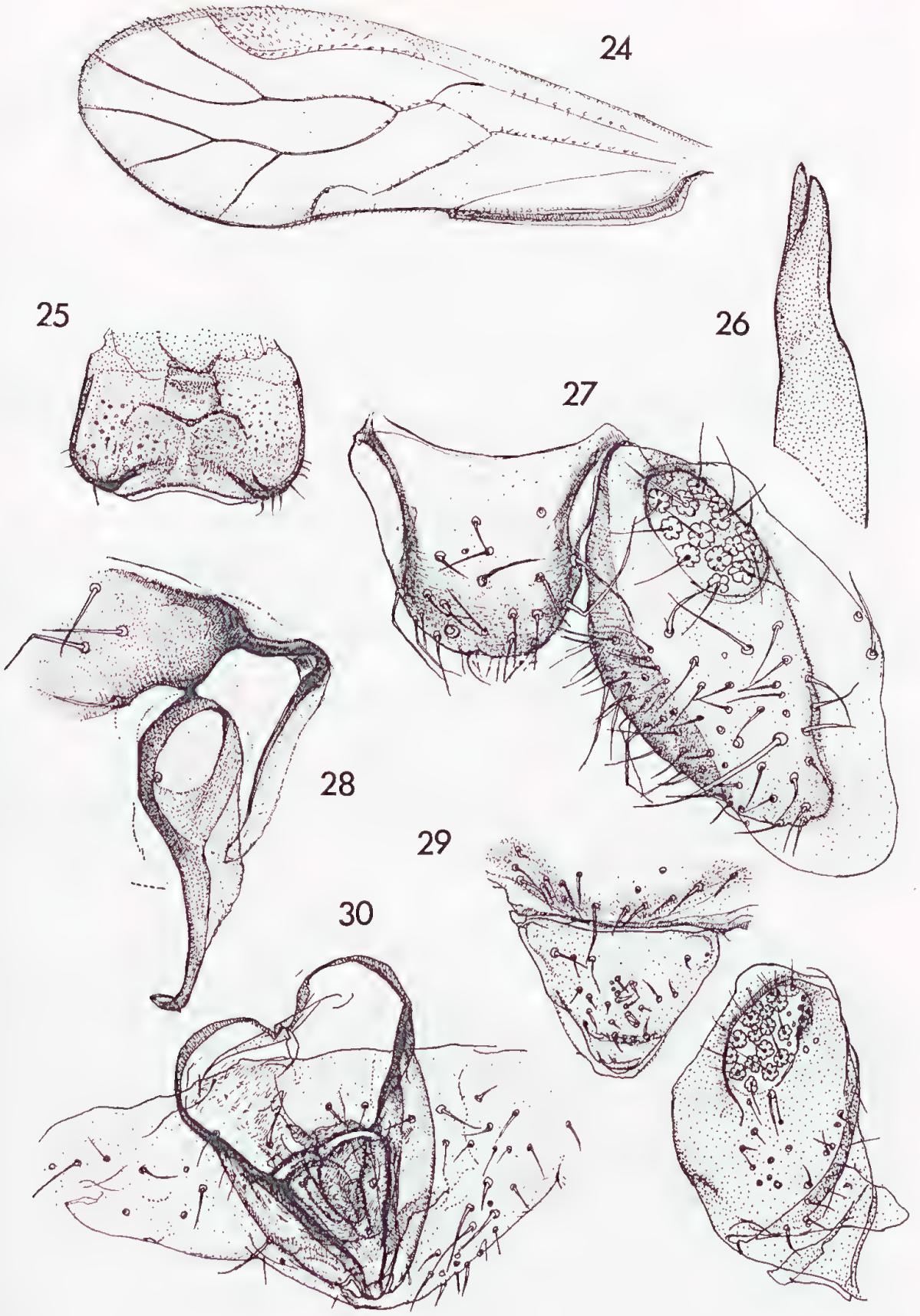
MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♀ , 23.v.1973 (C.N.S., A.S.S.) (AM).

STENOPSOCIDAE

Taeniostigma trickettae Smithers

Taeniostigma trickettae Smithers 1974. *J. Aust. ent. Soc.* 13:211, figs. 1-12,17.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♂ , 1 ♀ , 7 nymphs, 1.xi.1973, (C.N.S.); 1 ♀ , 2 nymphs, 15.xi.1973 (C.N.S., A.S.S.); 1 ♀ , 2 nymphs, 29.xi.1973



FIGURES. 24-30. — *Paracaecilius hylobius* sp. n. 24.♀ forewing, 25.♀ labrum, 26.♀ lacinia, 27.♀ epiproct and paraproct, 28.♀ gonapophyses, 29.♂ epiproct and paraproct, 30.♂ phallosome.

(C.N.S., G.F.S.); 1 ♀, 13.xi.1973 (C.N.S., A.S.S.); 7 nymphs, 30.i.1974 (C.N.S., A.S.S.); 3 nymphs, 22.iii.1974 (C.N.S., A.S.S.); 4 nymphs, 4.iv.1974, (C.N.S., A.S.S.); 1 ♂, 18.iv.1974 (C.N.S.); 1 ♂, 1 ♀, 4 nymphs, 2.v.1974 (C.N.S., A.S.S.); 1 ♀, 3 nymphs, 23.v.1974 (C.N.S.); 1 ♂, 1 ♀, 4 nymphs, 20.vi.1974 (C.N.S., A.S.S.); 1 nymph, 9.vii.1974 (C.N.S.); 1 nymph, 18.vii.1974 (C.N.S., A.S.S.); 1 ♂, 1 ♀, 1.viii.1974 (C.N.S., A.S.S.); 3 nymphs, 22.viii.1974 (C.N.S., A.S.S.); 1 ♂, 3 nymphs, 19.ix.1974 (C.N.S.); 1 ♀, 3 nymphs, 3.x.1974 (C.N.S.); 1 ♂, 22.x.1974 (C.N.S.); 7 nymphs, 7.xi.1974 (C.N.S.) (AM).

ECTOPSOCIDAE

Ectopsocus californicus (Banks)

Peripsocus californicus Banks 1903. *Jl N.Y. ent. Soc.* 11:237.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♀, 18.x.1973 (C.N.S., A.S.S.); 10 ♀, 4 nymphs, 1.xi.1973 (C.N.S.); 2 ♀, 15.xi.1973 (C.N.S., A.S.S.); 1 ♂, 29.xi.1973 (C.N.S., G.F.S.); 1 ♀, 13.xii.1973 (C.N.S., A.S.S.); 1 ♂, 30.i.1974 (C.N.S., A.S.S.); 1 ♀, 28.ii.1974 (C.N.S., A.S.S.); 1 ♂, 4.iv.1974 (C.N.S., A.S.S.); 1 ♂, 23.v.1974 (C.N.S.); 1 ♂, 3 ♀, 1.viii.1974 (C.N.S., A.S.S.); 1 ♂, 22.viii.1974 (C.N.S., A.S.S.); 2 ♂, 1 nymph, 19.ix.1974 (C.N.S.) (AM).

Ectopsocus punctatus Thornton and Wong

Ectopsocus punctatus Thornton and Wong, 1968. *Pacif. Insects Monogr.* 19:137, figs. 291-296.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♂, 7.xi.1974 (C.N.S.) (AM).

Ectopsocus perplexus sp. n.

MALE

COLORATION: (in alcohol). Head, palps. antennae, thorax and legs almost uniformly very pale brown, at most a little darker on vertex; abdomen pale with dark tubercular lobe, lateral patches and transverse comb showing up distinctly against pale background at end of abdomen. Fore wings (fig. 31) hyaline, very faintly tinged with brown; veins brown. Hind wings hyaline, almost colourless; veins pale brown.

MORPHOLOGY: Length of body: 1.7 mm. Head with scattered, well developed, erect setae. Epicranial suture indistinct. Lengths of flagellar segments: f_1:0.21 mm.; f_2:0.168 mm. Male antennae not greatly thicker than in female. Eyes fairly well developed, upper margin level with vertex, not greatly larger than in female. IO/D (Badonnel): 2.0; PO: 0.57. Anterior ocellus much smaller than lateral ocelli. Coxae and femora stout. Measurements of hind leg: F: 0.35 mm.; T: 0.62 mm.; t_1:0.15 mm.; t_2:0.07 mm.; rt: 2.2:1; ct: 12, 0. Fore wing length: 1.76 mm; fore wing width: 0.6 mm. Fore wings fairly narrow. Pterostigma a little wider distally than basally. Rs and M meet in a point, radial fork shorter than stem of Rs; margin with an occasional minute seta. Hind wing length: 1.36 mm.; hind wing width: 0.44 mm. Margin with a few minute setae between R_{2+3} and R_{4+5}. Rs-M crossvein fairly long. Epiproct simple, more heavily sclerotized distally than near base and bearing a few symmetrically arranged setae in distal half; hind margin rounded. Paraproct lightly sclerotized; trichobothrial field of eight setae. Sclerotizations of ninth tergite distinctive (fig. 32); posterior margin with "comb" and lateral margins sinuous, sclerotized in posterior half; dorsal plate bearing a median, posteriorly-directed, rugose lobe and a small, more truncate, rugose lobe anteriorly; laterally, margin of tergite with a small, sclerotized area the posterior margin of which carries a small "comb" of irregular teeth (fig. 32). Hypandrium (fig. 33). Phallosome (fig. 34).

FEMALE

COLORATION: (in alcohol). As in male.

MORPHOLOGY: Length of body: 1.7 mm. Lengths of flagellar segments: f_1:0.224 mm.; f_2:0.140 mm. IO/D (Badonnel): 2.0; PO: 0.57. No sexual dimorphism in antennal and eye characters but anterior ocellus equal to lateral ocelli in size in female. Measurements of hind leg: F: 0.32 mm.; T: 0.60 mm.; t_1:0.17 mm.; t_2:0.08 mm.; rt: 2:1; ct:13, 0. Fore wing length: 1.68 mm.; fore wing width: 0.56 mm. Fore wing venation and setae as in male. Hind wing length 1.4 mm.; hind wing width: 0.44 mm. Epiproct (fig. 35) well sclerotized, less so in middle area. Paraproct well sclerotized with a strongly sclerotized dorsal marginal band which extends, but is narrower, below trichobothrial field of nine setae; near its posterior end the marginal band bears a strong cone; a row of four widely-spaced setae lies below trichobothrial field and there is a short, strong seta in distal half. Subgenital plate (fig. 36). Gonapophyses (fig. 36).

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♂, (holotype), 1 ♀, (allotype), 18.x.1973 (C.N.S., A.S.S.). Paratypes: 1 ♂, 1 ♀, 18.x.1973 (C.N.S., A.S.S.); 2 ♀, 30.i.1974 (C.N.S., A.S.S.); 1 ♀, 13.xii.1973 (C.N.S., A.S.S.) (AM).

Holotype, allotype and paratypes in the Australian Museum.

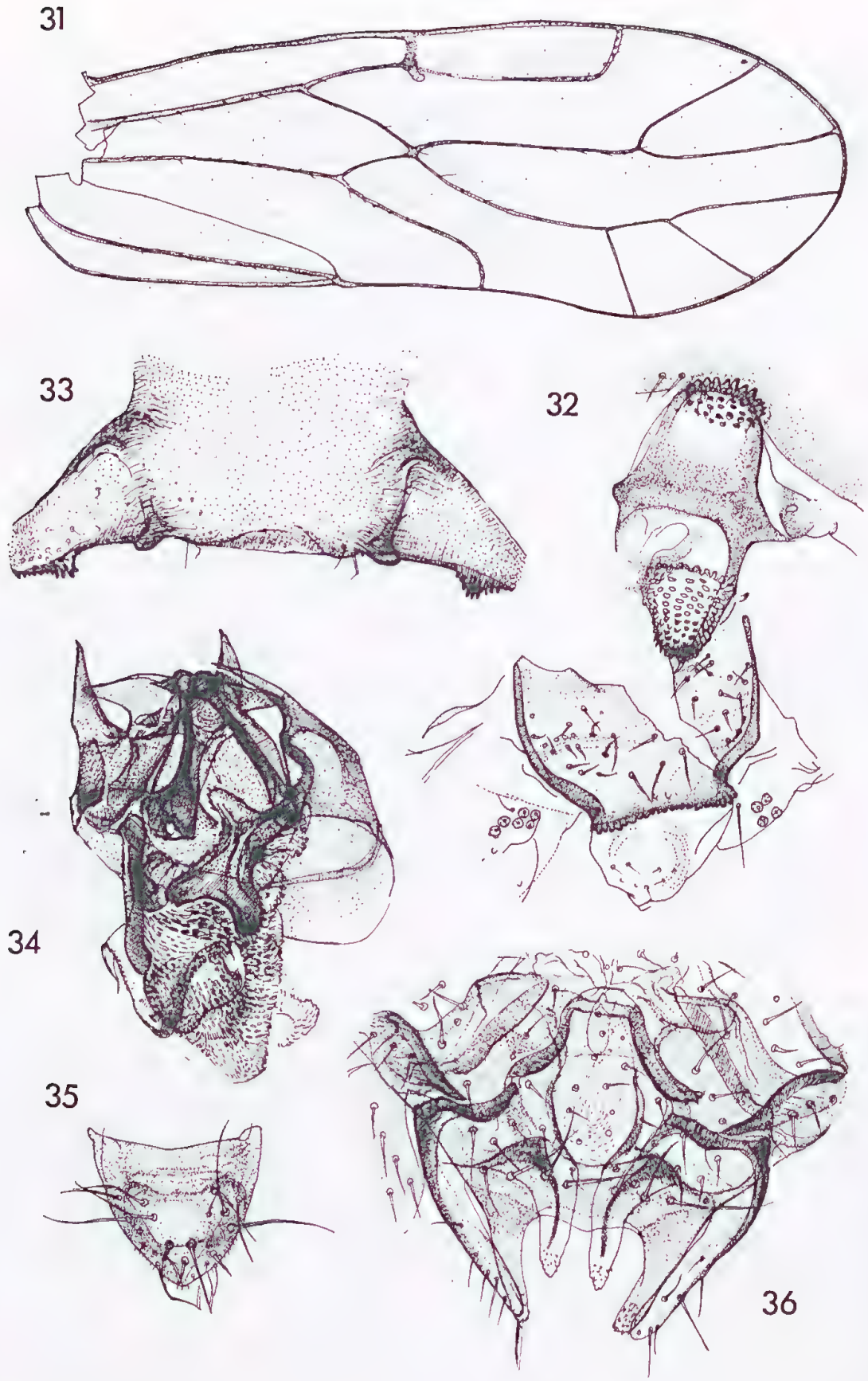
DISCUSSION: Thornton and Wong (1968) have grouped the species of *Ectopsocus* McLachlan of the Oriental and Pacific Regions into fourteen groups. *E. perplexus,* as it does not show any degree of sexual dimorphism, cannot be placed in the *ornatus, fullawayi, basalis, fenestratus, denervus, maindroni* nor *briggsi* groups. *E. perplexus* has the pterostigma broadened a little towards the distal end and the inner parameres of the male are fused; it is not, therefore, closely allied to the *perkinsi* group. The apical abdominal structures of the male preclude association with *E. dicroglossus* Thornton and Wong and *E. adelphos* Thornton and Wong and the *denotatus, titschacki* and *maindroni* groups have truncate lobes to the subgenital plate and those of the *cinctus* group are triangular. From species of the *hirsutus* group and from *E. pumilis* (Banks), *perplexus* differs in the distinctive form of the sclerifications of the apex of the male abdomen. It cannot, therefore, be placed with confidence in any of the species groups of Thornton and Wong (loc. cit.).

Ectopsocus pteridii sp. n.

MALE

COLOURATION: (in alcohol). Head pale brown, postclypeus with faint striations, a slightly darker spot between antenna base and compound eye; genae pale. Antennae pale brown. Eyes black. Ocelli pale. Maxillary palps pale brown. Thoracic nota pale brown, the parapsidal sutures appearing as fine dark lines. There is a faint suggestion of a darker lateral band running from behind eye to base of abdomen. Legs very pale brown; tibiae a little darker. Fore wings hyaline, very faintly tinged with brown; slightly darker areas occur at the Rs and M junction, where veins meet the wing margin and at the proximal end of the pterostigma. Veins brown. Hind wing hyaline. Veins brown. Abdomen very pale except for terminal structures.

MORPHOLOGY: Length of body: 1.4 mm. Head with postclypeus hardly bulging; anterior margin straight. Median epicranial and epistomial sutures very distinct. Lengths of flagellar segments: f_1:0.280 mm.; f_2:0.168 mm. Eyes fairly large, larger than in female and just reaching level of vertex. IO/D (Badonnel): 2.1; PO: 0.6. Ocelli large. Head with some long and stout setae in addition to more densely arranged smaller setae. Fore wing length: 1.6 mm.; fore wing width: 0.6 mm. Pterostigma slightly broader distally than



FIGURES 31-36. — *Ectopsocus perplexus* sp. n. 31.♂ forewing, 32.♂ sclerification of 9th tergite, posterior marginal comb and dorsal plate, with rugose lobe and irregular teeth, 33.♂ hypandrium, 34.♂ phallosome, 35.♀ epiproct, 36.♀ subgenital plate.

proximally. Rs and M meet in a point; M_1 arises opposite radial fork. Margin and veins with very short, widely separated setae, visible only with magnification x 100. Hind wing length: 1.2 mm.; hind wing width: 0.4 mm. A few marginal setae between R_{2+3} and R_{4+5}: Measurements of hind leg: F: 0.32 mm.; T: 0.53 mm.; t_1: 0.17 mm.; t_2:0.07 mm.; rt: 2.2:1; ct: 12, 0. Epiproct simple, lightly sclerotized, setose. Eighth and ninth tergites (fig. 37) characteristically sclerotized. Ninth tergite with apical "comb" of about 26 teeth, lateral borders sclerotized and converging slightly towards the rear. Eighth tergite extended posteriorly into a coarsely papillate lobe and with a small median field of papillae at the anterior edge; a lateral papillate area occurs on each side and the body of the tergite is well sclerotized. Phallosome (fig. 38) with complex sclerifications of the penial bulb in addition to fused internal parameres.

FEMALE

COLORATION: (in alcohol). As in male but a little darker.

MORPHOLOGY: Length of body: 1.4 mm. Head larger than in male; eyes smaller. Lengths of flagellar segments: f_1:0.196 mm.; f_2:0.112 mm. IO/D (Badonnel): 2.7; PO: 0.75. Ocelli large. Measurements of hind leg: F: 0.29 mm.; T: 0.48 mm.; t_1:0.14 mm.; t_2:0.07 mm.; rt: 2:1; ct: 10, 0. Fore wing length: 1.25 mm.; fore wing width: 0.48 mm. Epiproct rounded, well sclerotized, setose. Paraproct with a small double cone on hind margin. Gonapophyses (fig. 39) spermathecal entrance with characteristic and, for *Ectopsocus*, unusual sclerifications (fig. 39). Subgenital plate (fig. 40) with heavy internal sclerifications laterally and a median reticulate pattern internally. Margin between posterior lobes straight.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♂ (holotype), 1 ♀ (allotype), 13.xii.1973 (C.N.S., A.S.S.); Paratypes: 1 ♂ , 1♀ , 19.ix.1974 (C.N.S.); 1♀ , 1.viii.1974 (C.N.S., A.S.S.) (AM).

Holotype, allotype and paratypes in the Australian Museum.

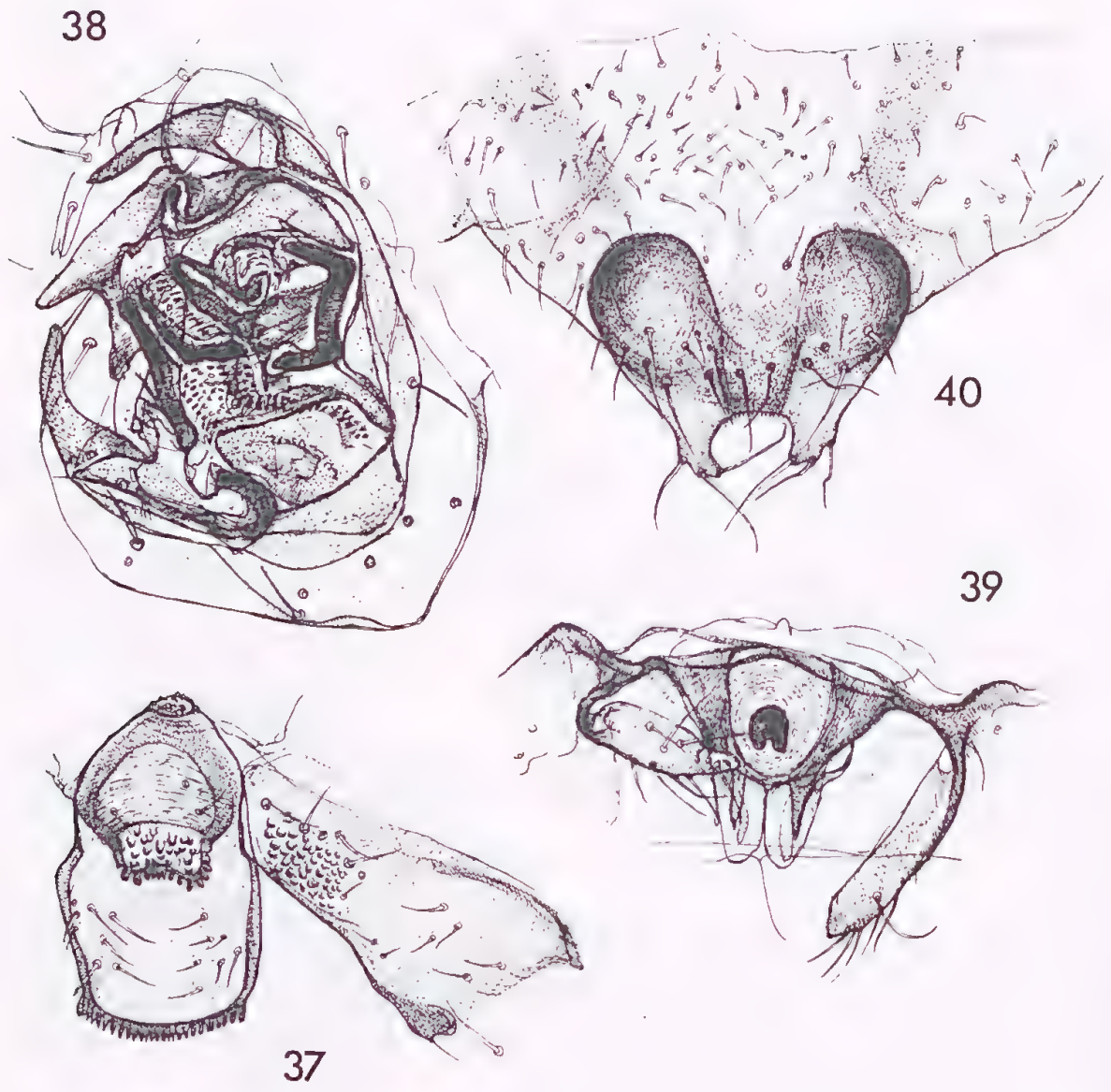
DISCUSSION: *Ectopsocus pteridii* is very similar to *E. punctatus* Thornton and Wong known from New Zealand, New Caledonia and Australia. The male differs in the proportions of the ninth tergite and in having the papillae of the ninth tergite larger and finer. In the female the dorsal valves are longer, the spermathecal entrance sclerifications differ and the margin of the subgenital plate between the posterior lobes is straight whereas in *E. punctatus* it is curved.

Ectopsocus parmatus sp.n.

MALE

COLORATION: (in alcohol). Head brown, median epicranial suture dark. Postclypeus without striations. Antennae and maxillary palps a little paler than head. Eyes black. Ocelli reddish. Thorax brown, the median posterior part of antedorsum pale. Legs pale brown. Fore wing hyaline, uniformly tinged with pale brown; veins dark. Hind wings hyaline, barely tinged with pale brown, veins brown. Abdomen pale except for sclerotized apical structures.

MORPHOLOGY: Length of body: 1.5 mm. Median epicranial suture very distinct. Postclypeus almost flat. Lengths of flagellar segments: f_1:0.28 mm.; f_2:0.17 mm. Eyes moderately large. IO/D (Badonnel): 2.6; PO: 0.8 Ocelli large. Measurements of hind leg: F: 0.38 mm.; T: 0.60 mm.; t_1:0.18 mm.; t_2:0.08 mm.; rt: 2.2:1; ct: 12,0. Fore wing length: 1.6 mm.; fore wing width: 0.7 mm. Pterostigma only very slightly wider distally. Rs and M meet in a point. R, R_1 and IA with strong setae. Other veins more sparsely setose, Cu_2 glabrous. Marginal setae from R_1 to wing apex in a double row. Hind wing length: 1.3



FIGURES 37-40. — *Ectopsocus pteridii* sp. n. 37.♂ 8th and 9th tergites, 38.♂ phallosome, 39.♀ gonapophyses and spermathecal entrance, 40.♀ subgenital plate.

mm.; hind wing width: 0.5 mm. Margin setose (about 10 setae) between R_{2+3} and wing apex. Hypandrium (fig. 41). Phallosome (fig. 42). Sclerification of ninth tergite (fig. 43) with distal "comb", a proximal area of papillae, a transverse row of papillae about a quarter of distance from base and with sclerotized lateral margins.

FEMALE — Unknown.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♂ (holotype), 4.iv.1974 (C.N.S., A.S.S.) (AM).

Holotype in the Australian Museum.

DISCUSSION: *Ectopsocus parmatus* belongs to the *E. cinctus* group of Thornton and Wong (1968) but can be distinguished from other species of that group by the form of the sclerification of the phallosome and of the ninth tergite.

Ectopsocus russulus sp.n.

FEMALE

COLORATION: (in alcohol). Head and thorax reddish brown; abdomen yellowish brown. Antennae, maxillary palps and legs pale brown. Eyes black. Fore wings tinged with reddish brown; veins dark brown. Hind wings very faintly tinged with brown; veins pale brown.

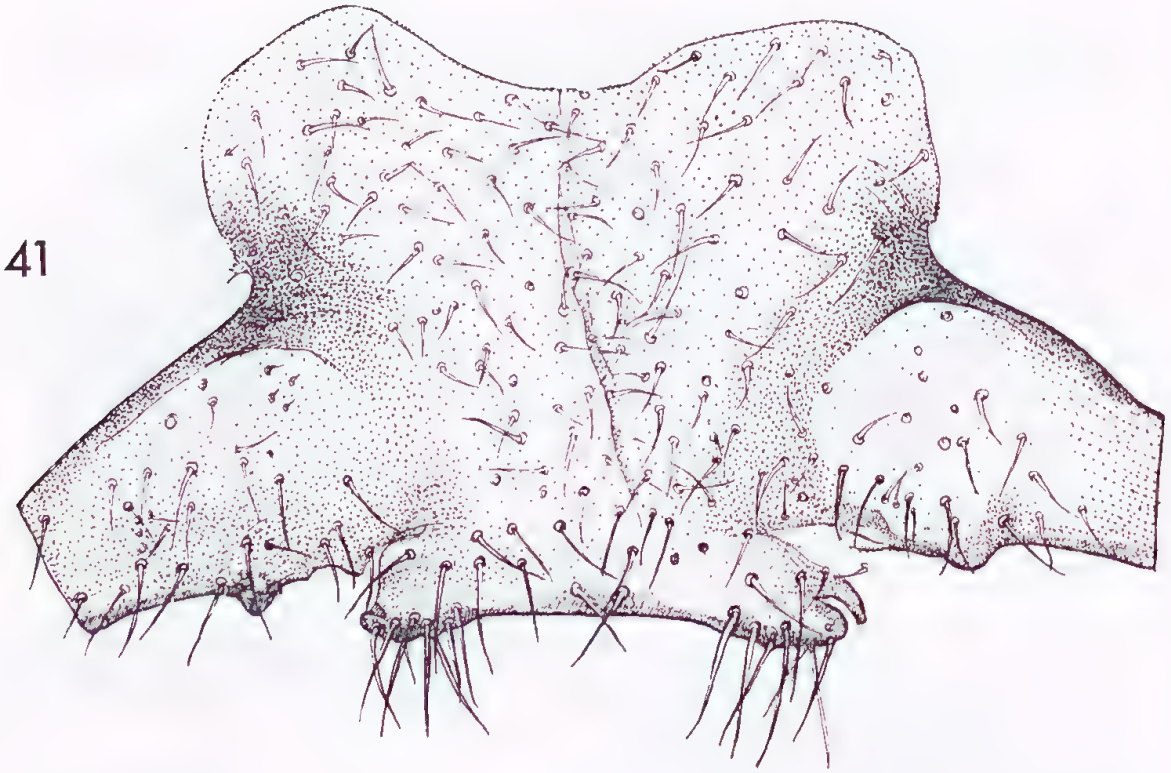
MORPHOLOGY: Length of body: 1.9 mm. Median epicranial suture very distinct. Head strongly setose. Eyes fairly large but not reaching level of vertex. IO/D (Badonnel): 3.0; PO: 0.6 Ocelli small, anterior ocellus only little smaller than lateral ocelli. Fore wing (fig. 44). Measurements of hind leg: F: 0.39 mm.; T: 0.63 mm.; t_1:0.21 mm.; t_2:0.08 mm.; rt: 2.6:1; ct: 11, 0. Fore wing length: 1.5 mm.; fore wing width: 0.6 mm. Pterostigma broadens a little towards apex. Rs and M meet in a point. Stem of Rs about as long as branches. (M_2 missing from right wing of holotype). Margin and veins (except Cu_2) strongly setose, a double row of setae on margin from Sc to R_{4+5}. Hind wing length: 1.3 mm.; hind wing width: 0.45 mm. Rs – M crossvein very long. Wing glabrous except for margin between R_{2+3} and wing apex; margin setae fine but fairly long. Epiproct triangular with rounded apex. Paraproct with small trichobothrial field, a row of six strong setae and very well-developed double marginal cone. Subgenital plate (fig. 45) with widely separated, rounded, posterior lobes, the margin between them straight, each lobe with four strong setae. Subgenital plate with row of six strong setae near hind border; a small, well sclerotized patch lies basad of each lobe near the sides of the plate. Gonapophyses (fig. 46) with ventral valve reduced to a vestige; dorsal valves broad, tapering, supported by a median sclerotization and with a blunt, spiculate apex; external valve elongate; an incomplete arch lies anterior to the membranous entrance to the spermatheca (fig. 46).

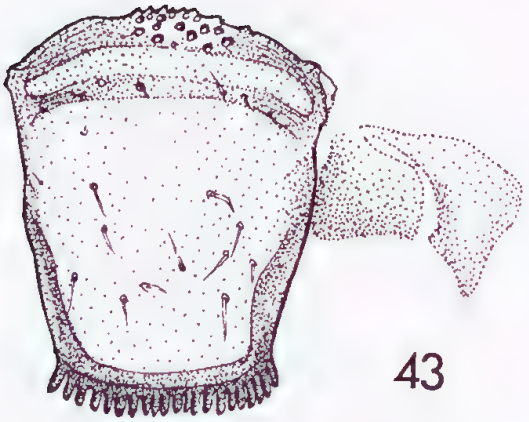
MALE — Unknown

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 2 ♀ (including holotype), 18.x.1973 (C.N.S., A.S.S.) (AM).

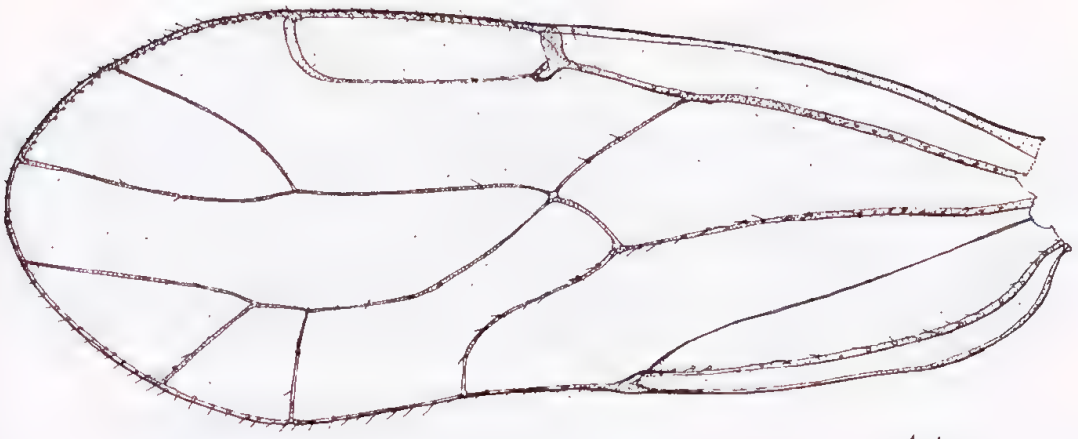
Holotype and paratype in the Australian Museum.

DISCUSSION: Only two species of *Ectopsocus* are known which lack a ventral valve to the gonapophyses, *E. vachoni* Badonnel and *E. spiculatus* New. In these species, however, the margin of the subgenital plate bears spicules between the apical lobes and the lobes are shorter than in *E. russulus*.





FIGURES 41-43. — *Ectopsocus parmatus* sp. n. 41.♂hypandrium, 42.♂phallosome, 43.♂sclerification of 9th tergite.



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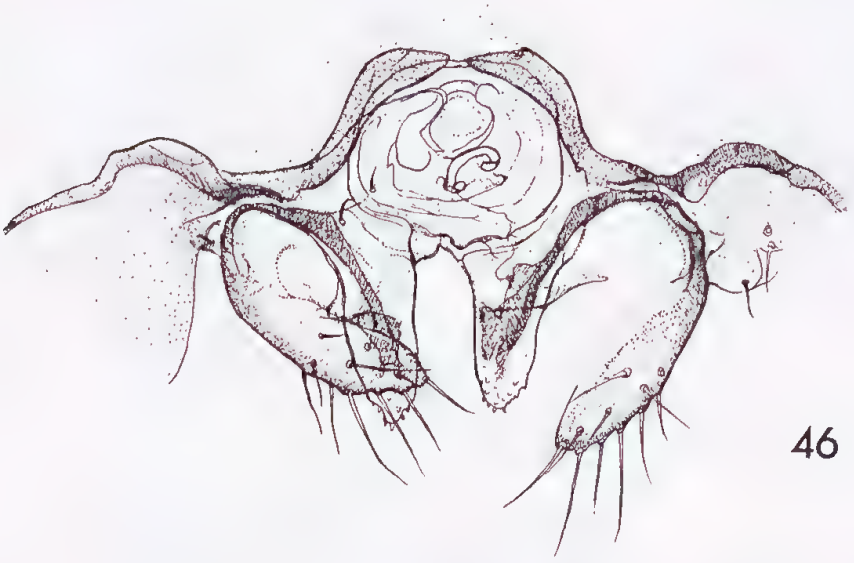

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FIGURES 44-46. *Ectopsocus russulus* sp. n. 44. ♀ forewing, 45. ♀ subgenital plate, 46. ♀ gonapophyses and spermathecal entrance.

Ectopsocus albiceps sp.n.

FEMALE

COLORATION: (in alcohol). Head creamy white. Median epicranial suture distinct. Labrum brown. Eyes black. Ocelli colourless. Maxillary palp and antennae very pale, coloured as head. Thorax brown, with suggestion of a darker lateral line. Legs creamy white except for the brown coxae of the meso- and metathoracic legs. Fore wings (fig. 47) hyaline, with dark brown markings. Veins brown within and basad of the transverse band of colour, pale beyond. Hind wing hyaline, faintly tinged with brown in basal half, colourless beyond. Veins pale. Abdomen brown, segmentally banded, a little darker above.

MORPHOLOGY: Length of body: 1.7 mm. Median epicranial suture clear but not coloured. Head with dense clothing of setae. Lengths of flagellar segments: f_1:0.294 mm.; f_2:0.182 mm.; pedicel relatively large, flagellar segments narrow bearing setae much longer than their diameters. Eyes fairly large, but not reaching level of vertex. IO/D (Badonnel): 2.1; PO: 0.66. Ocelli small. Lacinia apically divided as usual in the genus, outer tooth much larger than inner. Measurements of hind leg: F: 0.38 mm.; T: 0.63 mm.; t_1:0.20 mm.; t_2:0.08 mm.; rt: 2.3:1; ct: 15, 0. Fore wing length: 1.7 mm.; fore wing width: 0.65 mm. Fore wing (fig. 47) with R_1 parallel to wing margin in pterostigmal area, i.e., the posterior margin of the pterostigma obviously slightly concave and pterostigma equally broad for its whole length. Stigmapophysis large and conspicuous. Rs and M meet in a point. Rs before bifurcation as long as R_{4+5}; Cu_1 strongly recurved near wing margin. Margin glabrous, veins with a few very fine setae. Hind wing glabrous except for a few marginal setae between R_{2+3} and R_{4+5}. Epiproct triangular, bearing few setae but two of which, near the centre of the epiproct, are very long. Paraprocts with a small trichobothrial field and a row of five setae adjacent to it, there is a posterior field of small, evenly spaced setae; hind margin with a short double cone. Subgenital plate (fig. 48). Gonapophyses (fig. 49) with an unusual, broad, chitinized band from one external valve to the other; ventral valves exceptionally broad.

MALE

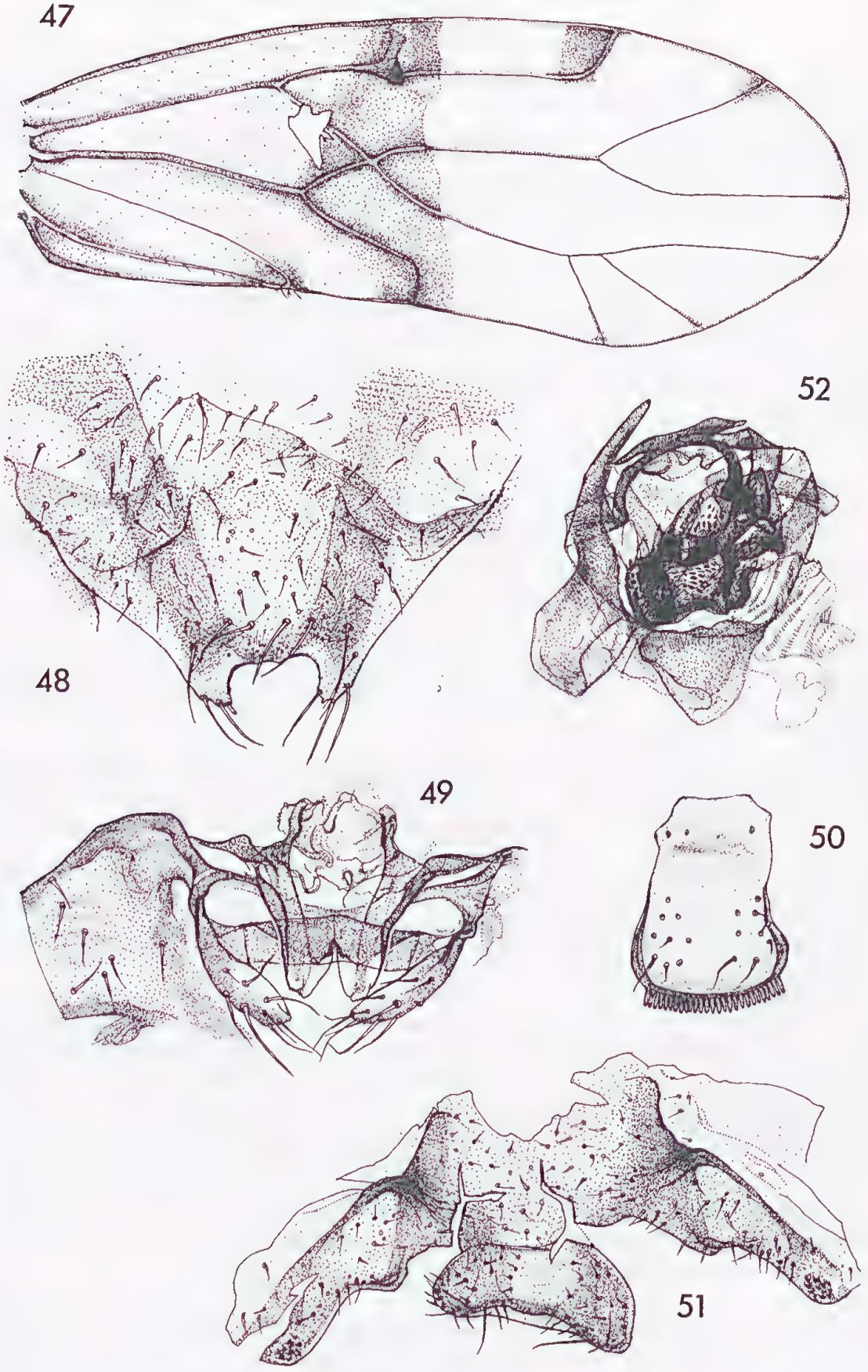
COLORATION: (in alcohol). Similar to female but some brown markings on vertex, especially near median epicranial suture, which is dark brown. Abdomen paler than in female, but each segment clearly marked in brown above.

MORPHOLOGY: Length of body: 1.8 mm. Median epicranial suture very distinct. Lengths of flagellar segments: f_1 : 0.336 mm.; f_2:0.252 mm. Eyes large, much larger than in female and reaching level of vertex. IO/D (Badonnel): 1.4; PO: 0.75. Ocelli very large, especially the lateral ocelli. Measurements of hind leg: F: 0.39 mm.; T: 0.66 mm.; t_1:0.20 mm. (second tarsal segment missing on allotype); ct: 18, 0. Fore wing length: 1.8 mm.; fore wing width: 0.7 mm. Venation as in female. Ninth abdominal tergite with posterior "comb" and strongly sclerotized lateral margins (fig. 50). Hypandrium (fig. 51). Phallosome (fig. 52).

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 3 ♀ (holotype and paratypes), 15.xi.1973 (C.N.S., A.S.S.); 2 ♂ (allotype and paratype), 28.ii.1974 (C.N.S., A.S.S.) (AM).

Holotype, allotype and paratypes in the Australian Museum.

DISCUSSION: *Ectopsocus albiceps* can be distinguished from all other members of the genus by its distinctive wing pattern as well as genitalic features and body colour pattern. This pattern in life gives the impression that the insect has lost the hind part of its body and appears to be much shorter than it is.



FIGURES 47-52 — *Ectopsocus albiceps* sp. n. 47.♀ forewing, 48.♀ subgenital plate, 49.♀ gonapophyses, 50.♂ 9th abdominal tergite, 51.♂ hypandrium, 52.♂ phallosome.

PERIPSOCIDAE

Peripsocus milleri (Tillyard)

Peripsocopsis milleri Tillyard 1923. *Trans. N.Z. Inst.* 54:195, fig. 20, pl. 18, fig. 14.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♂, 1.xi.1973 (C.N.S.); 1 ♂, 29.xi.1973 (C.N.S., A.S.S.); 1 ♂, 1 ♀, 30.i.1974 (C.N.S., A.S.S.); 2 ♀, 4.iv.1974 (C.N.S., A.S.S.); 1 ♂, 2.v.1974 (C.N.S., A.S.S.) (AM).

Peripsocus maoricus (Tillyard)

Peripsocopsis maoricus Tillyard 1923. *Trans N.Z. Inst.* 54:194, fig. 18, pl. 18, fig. 12.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♂, 8 ♀, 5 nymphs, 18.x.1973 (C.N.S., A.S.S.); 2 ♂, 19 ♀, 5 nymphs, 1.xi.1973 (C.N.S., A.S.S.); 12 ♂, 9 ♀, 8 nymphs, 15.xi.1973 (C.N.S., A.S.S.); 2 ♀, 1 nymph, 29.xi.1973 (C.N.S., G.F.S.); 3 ♀, 9 nymphs, 13.xii.1973 (C.N.S., A.S.S.); 1 ♀, 22.iii.1974 (C.N.S., A.S.S.); 1 ♂, 1 nymph, 22.viii.1974 (C.N.S., A.S.S.) (AM).

Peripsocus tillyardi New

Peripsocus tillyardi New 1973. *J. Aust. ent. Soc.* 12:343, figs. 11-13.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♂, 4 ♀, 4 nymphs, 1.xi.1973 (C.N.S.); 4 ♂, 3 ♀, 1 nymph, 15.xi.1973 (C.N.S., A.S.S.); 1 ♂, 1 ♀, 13.xii.1973 (C.N.S., A.S.S.); 1 ♂, 1 ♀, 22.iii.1974 (C.N.S., A.S.S.); 1 ♀, 18.iv.1974 (C.N.S.); 1 ♀, 2.v.1974 (C.N.S., A.S.S.); 4 ♀, 23.v.1974 (C.N.S.); 1 ♂, 20.vi.1974 (C.N.S., A.S.S.); 1 ♀, 19.ix.1974 (C.N.S.) (AM).

Peripsocus hamiltonae sp.n.

FEMALE

COLORATION: (in alcohol). Head brown with irregular confluent darker spots on either side of median epicranial suture, across hind part of vertex and adjacent to compound eyes. A dark spot between antenna base and eye. Postclypeus with anteriorly convergent brown stripes which meet in midline. Labrum dark brown. Genae pale brown. Antennae brown. Eyes black. Ocellar tubercle very dark brown. Maxillary palp uniformly dark brown. Thorax as in male but with pale areas a little more extensive and with a pale fine median midline on antedorsum. Fore wing pattern (fig. 56) in various shades of brown.

MORPHOLOGY: Length of body: 2.0 mm. Epicranial suture distinct. Lengths of flagellar segments: f_1:0.35 mm.; f_2:0.27 mm. Antennae fine. Eyes small, much smaller than in male. IO/D (Badonnel): 2.1; PO: 0.71. Ocelli small. Measurements of hind leg: F: 0.5 mm.; T: 0.95 mm.; t_1: 0.22 mm.; t_2:0.10 mm.; rt: 2.2:1. Fore wing length: 3.0 mm.; fore wing width: 1.2 mm. Fore wing venation (fig. 56). Epiproct well sclerotized, especially laterally and in distal half; hind margin rounded. Paraproct well sclerotized with large trichobothrial field. Subgenital plate (fig. 57). Gonapophyses (fig. 58) with strong ventral valve; dorsal valve very broad, dorsal part folded in distal half and with long marginal setae and a posterior field of well developed papillae. External valve developed into a double lobe.

MALE

COLORATION: (in alcohol). Vertex brown, with a dark brown patch on each side of median epicranial suture. Frons dark brown. Postclypeus brown with darker, anteriorly, converging stripes which do not meet in the midline. Labrum dark brown. Genae brown. Antennae brown. Eyes black. Ocelli on very dark tubercle. Maxillary palp brown, apical segment not darker than third segment. Thorax dark brown above, including sutures,

except for a small, slightly paler area where lateral lobes are in contact and along posterior margin of lateral lobes. Fore and middle legs with pale coxae and femora, tibiae and tarsi dark brown; hind legs almost uniformly brown. Fore wings similar to that of female (fig. 56). Wings in various shades of brown. Distal half of pterostigma and stigmapophysis very dark brown; an irregular band a little darker than rest of membrane crosses wing from stigmapophysis to nodulus. Hind wings faintly tinged with brown. Abdomen pale, with irregular brown markings segmentally arranged; genital segments dark brown.

MORPHOLOGY: Length of body: 2.0 mm. Head small. Median epicranial suture very distinct. Eyes very large, reaching above level of vertex. IO/D (Badonnel): 0.54; PO: 0.84. Ocelli small, arranged on a circular tubercle, the anterior ocellus very small. Epiproct (fig. 53) with a broad, sclerotized marginal band, lightly setose but with four strong setae on posterior margin. In the allotype specimen (illustrated) setae have been lost but the alveoli indicate their position. Paraproct broad, rounded, with a large trichobothrial field occupying at least half of the paraproct. Hypandrium (fig. 54). Phallosome (fig. 55).

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1♀ (holotype), 1♂ (allotype) (specimen damaged), 1.viii.1974 (C.N.S., A.S.S.); Paratype: 1♀, 9.vii.1974 (C.N.S.) (AM).

Holotype, allotype and paratype in the Australian Museum.

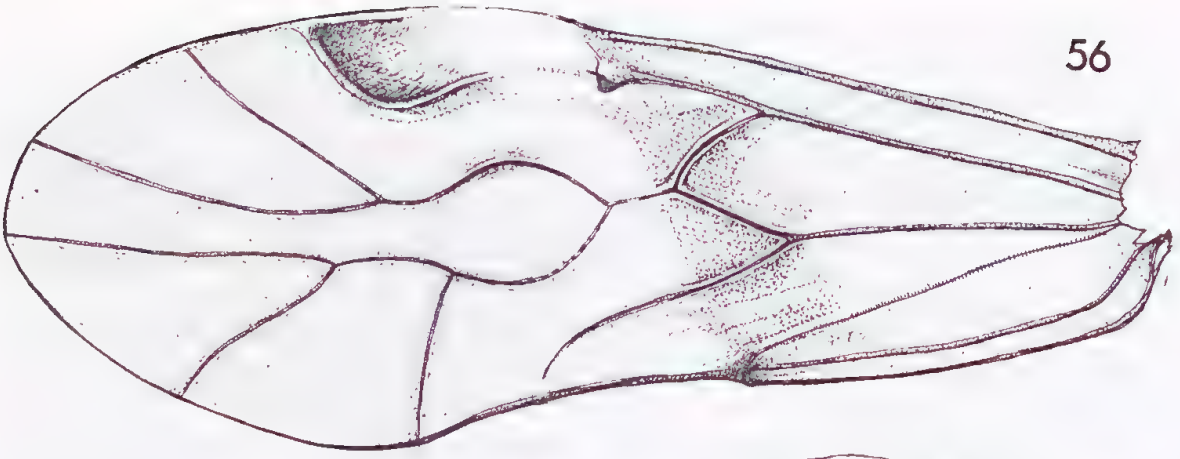
DISCUSSION: This species resembles *Peripsocus maoricus* (Tillyard) in general appearance but the wing colour is darker. It differs in that the male phallosome tapers anteriorly and lacks the three distinct posterior lobes. In the female the posterior lobe of the subgenital plate tapers more than in *P. maoricus*. *P. maoricus* lacks the double lobing of the external valve. This species is named for Mrs. Barbara Hamilton, as a mark of appreciation of her work with schoolchildren visiting Muogamarra Nature Reserve.

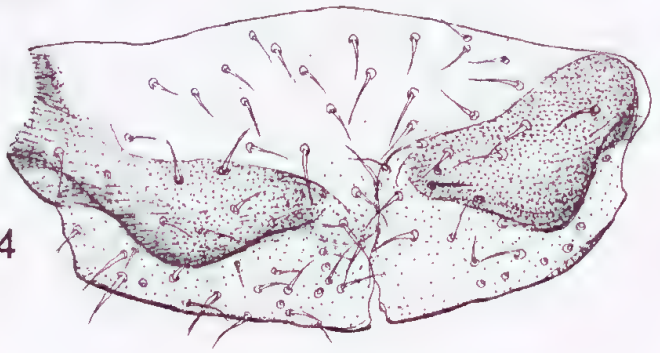
Peripsocus roseus sp.n.

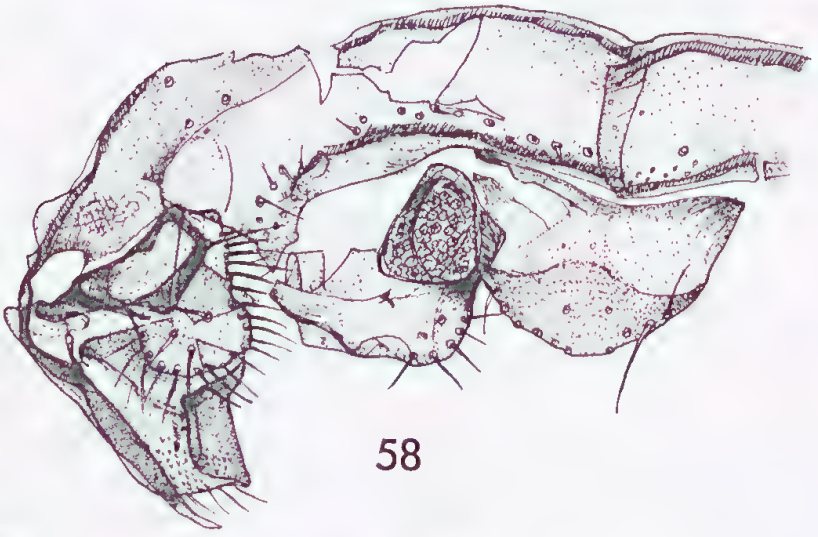
MALE

COLORATION: (in alcohol). Head pale yellowish brown with brown markings. Median epicranial suture dark brown, anterior arms a little paler. Vertex mottled brown, anterior to middle of eyes pale yellowish brown. Frons with a small dark triangle immediately in front of ocellar triangle, laterally paler. Postclypeus pale, without obvious striations. Labrum pale yellowish brown. Genae pale. Antennae uniformly pale yellowish brown. Eyes black. Ocellar tubercle pale as are the maxillary palps. Mesothoracic notum pale with brown lateral lobes and the antedorsum brown, divided by a longitudinal pale line; scutellum pale. Legs pale yellowish brown. Fore wings (fig. 59) hyaline and the veins pale except for the following which are brown: basal section of Rs, M after separation from M + Cu, basal section of Rs + M, basal half of stem of radial fork, R_{2+3}, distal part of R_{4+5}, distal part of Cu_1, distal half of stem of M after separation from Rs, rest of M and its branches except for basal part of M, and the nodulus. Distal half of pterostigma reddish in life. This colour pattern gives the appearance of a hyaline wing with a partly reddish pterostigma and with the vein system peculiarly broken. Hind wings hyaline, veins brown to pale brown in anterior half of wing, those in posterior half almost colourless. Abdomen evenly pale yellowish brown, the sclerifications of the penial bulb showing through ventrally at the apex as a dark spot.

MORPHOLOGY: Length of body: 1.5 mm. Epicranial suture very distinct, the anterior arms touching anterior margins of compound eyes. Lengths of flagellar segments: f_1:0.308 mm.; f_2:0.280 mm. Eyes very large, reaching above level of vertex.







FIGURES 53-58. — *Peripsocus hamiltonae* sp. n. 53. ♂ epiproct, 54. ♂ hypandrium, 55 ♂ phallosome, 56. ♀ forewing, 57 ♀ subgenital plate, 58 ♀ gonapophyses.

IO/D (Badonnel): 0.55; PO: 0.90. Ocelli fairly small, ovoid, the anterior ocellus not smaller than lateral ocelli. Lacinia (fig. 60) very narrow, in apical part, with bifid apex. Measurements of hind leg: F: 0.22 mm.; T: 0.77 mm.; t_1:0.20 mm.; t_2:0.08 mm.; rt: 2.3:1; ct: 13, 0. Femora narrow and almost parallel sided. Fore wing length: 2.6 mm.; fore wing width: 1.12 mm. Pterostigma with strongly curved hind margin in distal half giving a strongly broadened pterostigma. Hypandrium simple, setose lightly sclerotized with very small, median margination. Phallosome (fig. 61).

FEMALE

COLORATION: (in alcohol). Head pale yellowish brown, with brown markings. These differ considerably from those of the male and consist of a spot mesad of each compound eye, a spot on each side of the median epicranial suture about half way along its length, three tiny spots anterior to the ocellar triangle on the frons and clearcut, anteriorly convergent postclypeal stripes. In addition there is a small, indistinct mark behind the eyes. Labrum brown. Scape and pedicel pale brown, flagellum pale yellowish brown. Eyes black. Thorax as in male, but pigmentation darker. Fore wings (fig. 62) similar to male but darkened areas more extensive and darker; pterostigma in life coloured reddish as in male but brown when preserved in alcohol. Legs brownish. Abdomen pale, terminal structures brown.

MORPHOLOGY: Length of body: 1.9 mm. Epicranial suture distinct. Length of flagellar segments: f_1:0.28 mm.; f_2:0.25 mm. Flagellum fine. Eyes small, upper margin much lower than vertex in strong contrast to eyes of male. IO/D (Badonnel): 2.0; PO: 0.66. Ocelli ovoid, the anterior ocellus smaller than lateral ocelli. Lacinia strongly narrowed in distal half as in male. Measurements of hind leg: F: 0.35 mm.; T: 0.7 mm.; t_1:0.17 mm.; t_2:0.08 mm.; rt: 2:1; ct: 10, 0. Femora almost parallel sided; ctenidiobothria sparse on tibiae, especially proximally. Fore wing length: 2.36 mm.; fore wing width: 1.00 mm. Fore wings broad (fig. 62); venation as in figure. Epiproct (fig. 63). Subgenital plate (fig. 64) with a short broad, posterior lobe. Gonapophyses (fig. 65).

MATERIAL: Muogamarra Nature Reserve, N.S.W. 1 ♂ (holotype), 22.viii.1974 (C.N.S., A.S.S.); 1 ♀ (allotype), 1.xi.1973 (C.N.S., A.S.S.). Paratypes: 1 ♂, 1 ♀, 15.xi.1973 (C.N.S., A.S.S.); 1 ♀, 22.viii.1974 (C.N.S., A.S.S.); 1 ♂, 18.iv.1974 (C.N.S.) (AM).

Holotype, allotype and paratypes in the Australian Museum.

DISCUSSION: The wing pattern of *Peripsocus roseus* is very distinctive. The veins have the appearance of being broken in several places due to some sections of the veins being very dark whilst adjacent sections are almost colourless; also, the reddish pterostigma in life is distinctive. The sclerotizations of the male phallosome are characteristic.

PSEUDOCAECILIIDAE

Pseudocaecilius lachlani Enderlein

Pseudocaecilius lachlani Enderlein 1903. *Ann. hist.-nat. Mus. hung.* 1:263, pl. V. fig. 30.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♂, 4 nymphs, 18.xi.1973 (C.N.S., A.S.S.); 3 ♂, 1 ♀, 1 nymph, 1.xi.1973 (C.N.S.); 1 ♀, 15.xi.1973, (C.N.S., A.S.S.); 2 ♂, 2 nymphs, 29.xi.1973 (C.N.S., G.F.S.); 1 ♂, 13.xii.1973 (C.N.S., A.S.S.); 1 ♀, 28.ii.1974 (C.N.S., A.S.S.); 2 ♀, 4.iv.1974 (C.N.S., A.S.S.); 1 ♂, 18.iv.1974 (C.N.S.); 1 ♂, 9.vii.1974 (R.D.B.); 1 ♂, 18.vii.1974 (C.N.S., A.S.S.); 1 ♂, 3 ♀, 1.viii.1974 (C.N.S., A.S.S.); 1 ♀, 19.ix.1974 (C.N.S.); 1 ♀, 22.x.1974 (C.N.S.) (AM).

FIGURES 59-65. — *Peripsocus roseus* sp. n. 59. ♂ forewing, 60 ♂ whole lacinia, 61. ♂ phallosome, 62. ♀ forewing, 63. ♀ epiproct, 64. ♀ subgenital plate, 65 ♀ gonapophyses.

Heterocaecilius brunellus (Tillyard)

Caecilius brunellus Tillyard 1923. *Trans. N.Z. Inst.* 54:190, fig. 15; pl. 18, fig. 10.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♂, 2 ♀, 3 nymphs, 1.xi. 1973 (C.N.S.); 1 ♂, 1 ♀, 1 nymph, 13.xii.1973 (C.N.S., A.S.S.); 1 ♂, 1 ♀, 30.i.1974 (C.N.S., A.S.S.); 1 ♂, 1 ♀, 4.iv.1974 (C.N.S., A.S.S.); 1 ♀, 1 ♂, 1 nymph, 18.iv.1974 (C.N.S.); 1 ♀, 2.v.1974 (C.N.S., A.S.S.); 1 ♂, 2 ♀, 2 nymphs, 23.v.1974 (C.N.S.); 4 ♂, 6 ♀, 2 nymphs, 20.vi.1974 (C.N.S., A.S.S.); 3 ♂, 1 ♀, 9.vii.1974 (C.N.S.); 1 ♂, 4 ♀, 2 nymphs, 18.vii.1974 (C.N.S., A.S.S.); 3 ♂, 2 ♀, 1.viii.1974 (C.N.S., A.S.S.); 1 ♂, 3 ♀, 3 nymphs, 19.ix.1974 (C.N.S.); 2 ♂, 3 ♀, 5 nymphs, 22.x.1974 (C.N.S.); 2 ♀, 7.xi.1974 (C.N.S.); 1 ♂, 2 ♀, 2 nymphs, 21.xi.1974 (C.N.S.) (AM).

Lobocaecilius monicus Lee and Thornton

Lobocaecilius monicus Lee and Thornton 1967. *Pacif. Insects Monogr.* 16:86, figs. 137-143.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♀, 28.ii.1974 (C.N.S., A.S.S.); 1 ♀, 4.iv.1974 (C.N.S., A.S.S.); 1 ♀, 2.v.1974 (C.N.S., A.S.S.); 2 ♀, 23.v.1974 (C.N.S.); 2 ♂, 2 ♀, 1 nymph, 20.vi.1974 (C.N.S., A.S.S.); 3 ♂, 1 ♀, 18.vii.1974 (C.N.S., A.S.S.); 1 ♂, 1 ♀, 22.x.1974 (C.N.S.) (AM).

Pseudoscotiella tanei sp. n.

MALE

COLORATION: (in alcohol). Head dark brown except for the slightly paler frons. Antennae brown. Eyes deep purple. Ocelli pale, without any obvious centripetal pigmentation; tubercle coloured as rest of head. Maxillary palps very pale. Mesonotum dark brown except for a paler area where lateral lobes meet and the scutellum. Legs very pale except for pale brown tibiae and tarsi. Fore wings (fig. 66) hyaline with brown markings. Hind wing (fig. 67) hyaline, markings pale brown. Abdomen pale with some irregular, segmentally arranged pale brown marks; terminal structures brown.

MORPHOLOGY: Length of body: 1.7 mm. Median epicranial suture very distinct, anterior arms less so but still quite evident. Vertex fairly flat with large, scattered, setae; those towards back of vertex being exceptionally long, longer than distance from median epicranial suture to eye. A row of 6 strong setae occurs on the back of the vertex, three on each side. Lengths of flagellar segments: f_1: 0.378 mm; f_2 0.238 mm. Flagellum stongly setose. IO/D (Bandonnel): 2.7; PO: 0.8. Ocelli small. Measurements of hind leg: F: 0.370 mm; T: 0.40 mm; t_1: 0.63 mm; t_2: 0.15 mm; rt: 4.1:1; ct: 9, 0. Femora narrow, slightly curved. Tibiae devoid of ctenidiobothria in basal half. Fore wing length: 1.7 mm; fore wing width 0.6 mm. Fore wing (fig. 66) with costa in pterostigma strongly setose; pterostigma with a few setae near anterior margin, otherwise glabrous. Pterostigma narrow, not as wide as areola postica. Rs almost straight after separation from M, with which it has a long confluence. R_{4+5} in line with stem of Rs. Cu_2 strongly bent near nodulus. Hind wing length: 1.3 mm; hind wing width: 0.4 mm. Margin with only a few crossing setae, these between R_{4+5} and M. Rs and M fused for a long length. Epiproct sparsely setose but with a strongly developed area of papillae. Paraprocts with a field of about 10 large trichobothria. Paraproct sparsely setose but with a very long seta near posterior margin. Hypandrium (fig. 68). Phallosome (fig. 69) with frame strongly sclerotized basally, less so posteriorly where the external parameres are broadened and have their apices diverging. Internal parameres fused apically, the apex upturned and divided into small points. Two strong posteriorly directed rods lying within the frame are separate and angled anteriorly.

FEMALE — Unknown.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♂ (holotype), 13.xii.1973 (C.N.S., A.S.S.) (AM).

Holotype in the Australian Museum.

DISCUSSION: Several species of *Pseudoscottiella* Badonnel have patterned wings. *Ps. tanei* differs from them all in details of the pigment pattern. It is somewhat similar to *Ps. ornatus* (Banks) from which it differs in the form of the sclerotized rods of the phallosome; it differs in this respect also from all other species.

This species is named for Mr. M. Tane, Ranger at Muogamarra Nature Reserve in appreciation of his help during the time material was being collected for this paper.

PHILOTARSIDAE

Aaroniella rawlingsi Smithers

Aaroniella rawlingsi Smithers 1969. *Rec. Canterbury Mus.* 8:324, figs. 163-168.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1♀ , 1.xi.1973 (C.N.S.); 1 ♂ , 23.v.1974 (C.N.S.); 1 ♀ , 18.vii.1974 (C.N.S., A.S.S.) (AM).

Austropsocus viridis (Enderlein)

Philotarsus viridis Enderlein 1903. *Ann. hist. –nat. Mus. hung* 1:209, pl. ix, fig. 53.

MATERIAL EXAMINED: Muogammara Nature Reserve, N.S.W. 1 ♀ , 1.xi.1973 (C.N.S.); 1 ♀ , 13.xii.1973 (C.N.S., A.S.S.); 2 ♀ , 30.i.1974 (C.N.S., A.S.S.); 1 ♀ , 4.iv.1974 (C.N.S., A.S.S.); 1 ♀ , 22.viii.1974 (C.N.S., A.S.S.); 1 nymph, 19.ix.1974 (C.N.S.); 1 ♂, 1 nymph, 7.xi.1974 (C.N.S.); 2 ♂, 21.xi 1974 (C.N.S.) (AM).

Austropsocus tibialis Thornton and New

Austropsocus tibialis Thornton and New 1977, *Aust. J. Zool. suppl. ser.* 54:30, figs. 116-124.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 5 ♀ , 2 nymphs, 18.x.1973 (C.N.S., A.S.S.); 1 ♂, 1 ♀ , 1.xi.1973 (C.N.S.); 3 ♀ , 1 nymph, 29.xi.1973 (C.N.S., G.F.S.); 2 ♀ , 28.ii.1974 (C.N.S., A.S.S.); 1 ♀ , 22.iii.1974 (C.N.S., A.S.S.); 1 ♀ , 4.iv.1974 (C.N.S., A.S.S.) 2 ♀ , 2 nymphs, 2.v.1974 (C.N.S., A.S.S.); 1 ♀ , 1 nymph, 23.v.1974 (C.N.S.); 1 ♂, 1 ♀ , 1.viii.1974 (C.N.S., A.S.S.); 1 ♂, 1 ♀ , 22.viii.1974 (C.N.S., A.S.S.); 1 ♂, 1 nymph, 19.ix.1974 (C.N.S.); 1 ♂ , 3.x.1974 (C.N.S.); 1 ♂ , 7.xi.1974 (C.N.S.) (AM).

Haplophallus ornatus Thornton and New

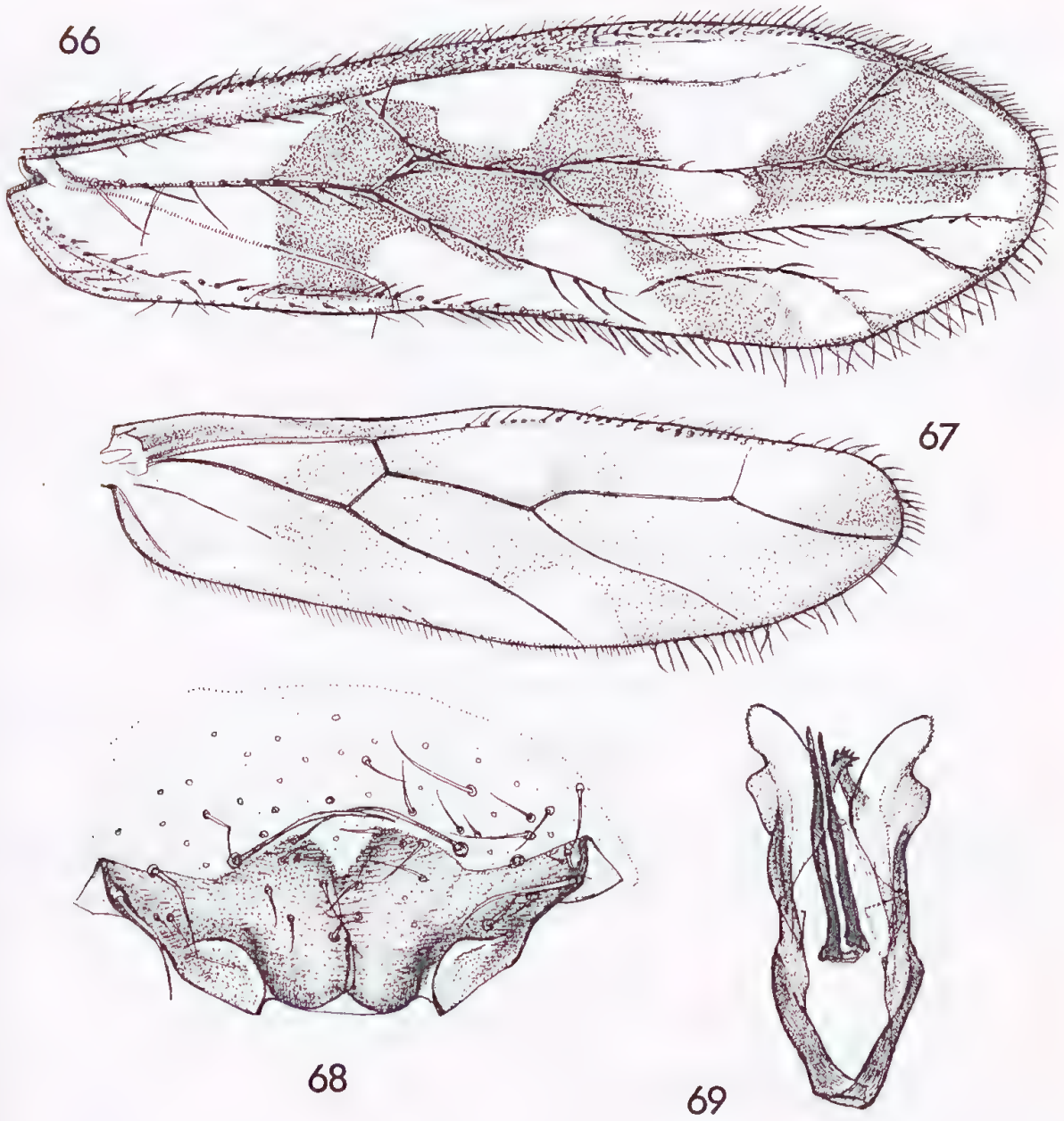
Haplophallus ornatus Thornton and New 1977. *Aust. J. Zool. suppl. ser.* 54:9, figs. 7-12.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♂ , 1.xi.1973 (C.N.S.); 1 ♀ , 2 nymphs, 22.iii.1974 (C.N.S., A.S.S.); 2 ♂, 18.iv.1974 (C.N.S.); 2 ♂, 1 ♀ , 2.v.1974 (C.N.S., A.S.S.); 2 ♂ , 1.viii.1974 (C.N.S., A.S.S.) (AM).

Haplophallus sinus Thornton and New

Haplophallus sinus Thornton and New 1977. *Aust. J. Zool. suppl. ser.* 54:20, figs. 62-68.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1♂ , 1 ♀ , 1 nymph, 18.x.1973 (C.N.S., A.S.S.); 1 ♂ , 2 ♀ , 1.xi.1973 (C.N.S.); 1 ♀ , 30.i.1974 (C.N.S., A.S.S.); 1 ♀ , 4.iv.1974 (C.N.S., A.S.S.); 2 ♀ , 2.v.1974 (C.N.S., A.S.S.); 1 ♀ , 23.v.1974 (C.N.S.); 1 ♀ , 22.viii.1974 (C.N.S., A.S.S.); 1 ♀ , 7.xi.1974 (C.N.S.) (AM).



FIGURES 66-69. — *Pseudoscottiella tanei* sp. n. 66.♂forewing, 67.♂hindwing, 68.♂hypandrium, 69.♂ phallosome.

Haplophallus guttatus (Tillyard)

Philotarsus guttatus Tillyard 1923. *Trans. N.Z. Inst.* 54:181, fig. 8.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1♂, 2 nymphs, 2.v.1974 (C.N.S., A.S.S.); 1♀, 23.v.1974 (C.N.S.); 2♂, 1♀, 20.vi.1974 (C.N.S., A.S.S.); 1♂, 1♀, 9.vii.1974 (C.N.S.); 1♀, 22.viii.1974 (C.N.S., A.S.S.); 1♀, 1 nymph, 19.ix.1974 (C.N.S.) (AM).

ELIPSOCIDAE

Spilopsocus ruidis Smithers

Spilopsocus ruidis Smithers 1963. *Pacif. Insects* 5 (4):894, figs. 19-25.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1♀, 9.vii.1974 (C.N.S.) (AM).

Paedomorpha gayi Smithers

Paedomorpha gayi Smithers 1963. *Proc. R. ent. Soc. Lond (B)* 32:32, figs. 1-6.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 2♀, 18.vii.1974 (C.N.S., A.S.S.); 1♀, 1.viii.1974 (C.N.S., A.S.S.) (AM).

PSOCIDAE

Blaste tillyardi Smithers

Blaste tillyardi Smithers 1969. *Rec. Canterbury Mus.* 8:338. figs. 197-204.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1♂, 1♀, 1 nymph, 18.x.1973 (C.N.S.); 1♂, 1♀, 1.xi.1973 (C.N.S.); 1♂, 1 nymph, 15.xi.1973 (C.N.S., A.S.S.); 1 nymph, 18.iv.1974 (C.N.S.); 1♂, 19.ix.1974 (C.N.S.) (AM).

Blaste taylori New

Blaste taylori New 1974. *J. Aust. ent. Soc.* 13:286, figs. 1-7.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1♂, 1♀, 7.xi.1974 (C.N.S.) (AM).

Blaste michaelseni (Enderlein)

Lasiopsocus michaelseni Enderlein 1907. *Fauna S.W. Aust.* 1(3):234, figs. 1-5.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1♂, 1.viii.1974 (C.N.S., A.S.S.) (AM).

Copostigma (Clematostigma) latimentula sp.n.

MALE

COLORATION: (in alcohol). Head creamy white with dark brown markings. A double row of irregular spots adjacent to median epicranial suture, across back of head and adjacent to compound eyes; each ocellus surrounded by a dark ring; a dark stripe in position of anterior arms of epicranial suture; a dark triangle anterior to ocelli; narrow

postclypeal stripes. Gena with a spot below eye and another near base of mandible. Antennae dark brown. Eyes black. Maxillary palps pale, third and fourth segments dark brown. Mesothoracic notum dark brown with a pale longitudinal stripe on antedorsum and with pale sutures. Legs pale, with a brown band at base and distal end of femora; distal end of tibiae brown, tarsi brown. Fore wings (fig. 70) hyaline; pterostigma and post pterostigmal mark dark brown; veins brown. Hind wings hyaline with brown veins. Ninth tergite and paraprocts very dark; base of phallosome shows through hypandrium as a dark curved line.

MORPHOLOGY: Length of body: 2.8 mm. Median epicranial suture fine but distinct. Lengths of flagellar segments: f_1:0.80 mm.; f_2: 0.80 mm. Antennae fine, with long fine setae many of which are slightly recurved. Eyes fairly large but not quite reaching level of vertex. IO/D (Badonnel): 1.9; PO: 0.77. Ocelli large. Measurements of hind leg: F: 0.56 mm.; T: 1.14 mm.; t_1:0.30 mm.; t_2:0.14 mm.; rt:2.1:1; ct: 18, 4. Fore wing length: 3.5 mm.; fore wing width: 1.3 mm. Fore wing (fig. 70) with narrow pterostigma; spur-vein very short. Sc evanescent distally but tending towards R_1; Rs and M confluent for a length. First section of Cu_{1a} little longer than second; epiproct (fig. 71) with two broad, lightly sclerotized lobes which stand erect. Paraproct (fig. 72). Hypandrium (fig. 73) distally upturned and apically bilobed. Phallosome (fig. 74) with strong basal fusion, broad. Ninth tergite very strongly sclerotized with strong transverse band along hind border.

FEMALE — Unknown.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 3 ♂, (including holotype), 17.iv.1975 (C.N.S.) (AM).

Holotype and paratypes in the Australian Museum.

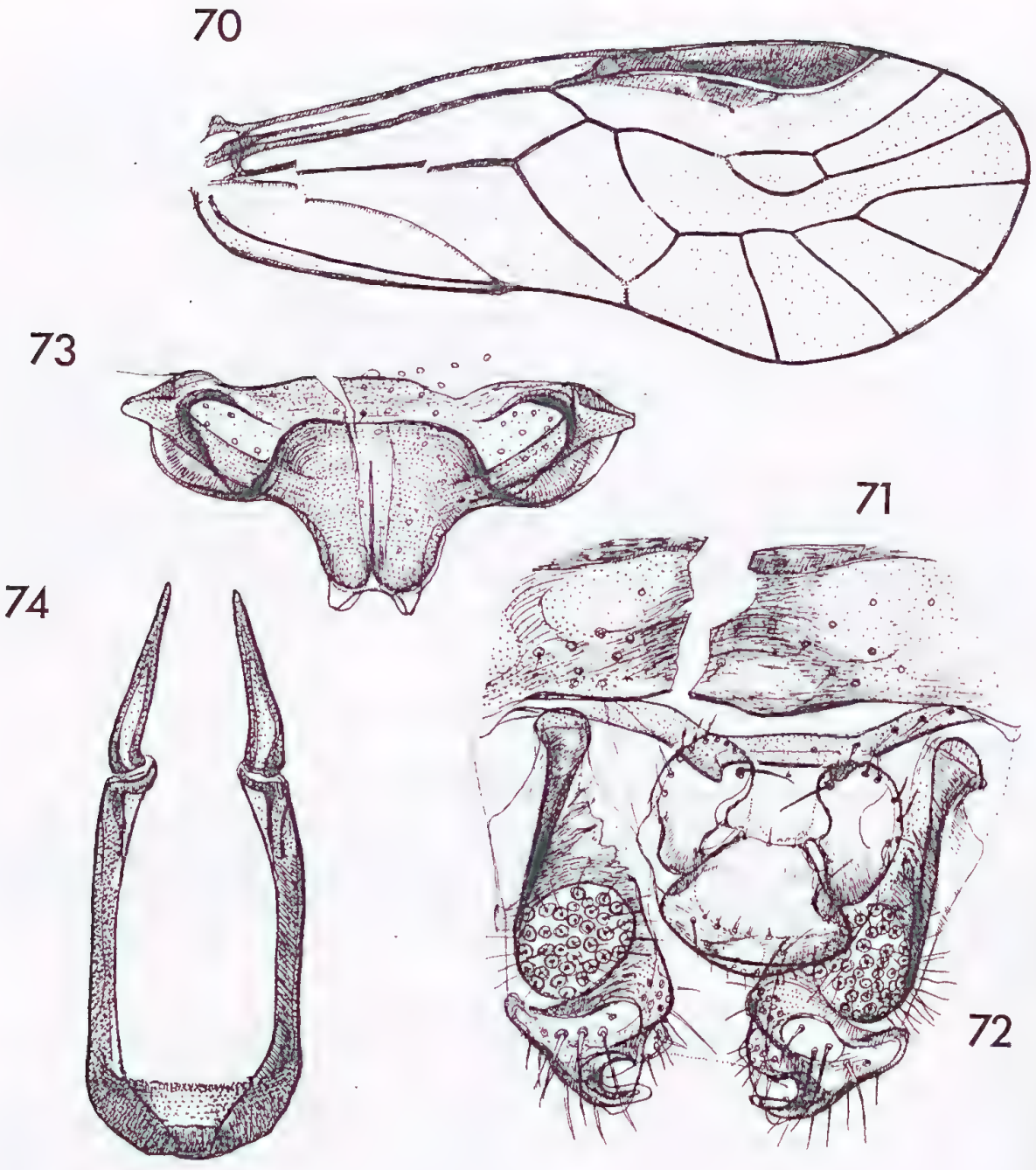
DISCUSSION: *Copostigma (Clematostigma) latimentula* belongs to that group of species in which the pterostigma is wholly darkly pigmented, narrow and long and in which the hypandrium is lobed. It differs from other species so far described in having a very broad-based phallosome and in having the posterior hypandrial lobes more extended.

Copostigma (Clematostigma) paula sp.n.

MALE

COLORATION: (in alcohol). Head brown with dark brown markings. A double row of irregular brown spots on each side of median epicranial suture, across back of head and adjacent to compound eyes; a dark band from lateral ocellus to antenna base; ocelli each encircled by a dark ring; a brown triangle anterior to median ocellus; postclypeus with stripes. Labrum dark brown. Gena with a spot near antenna base. Scape, pedicel and basal half of first flagellar segment pale brown, remainder of flagellum dark. Eyes black. Ocelli on pale tubercle but each ringed with dark brown. Maxillary palp with first and second segments pale, third and fourth very dark brown; mesonotum dark brown except for pale sutures and a pale median line on antedorsum. Coxae dark. Femora pale with a basal dark band and another about three quarters of way to tibia; tibia pale brown a little darker at each end. Tarsi brown. Fore wings (fig. 75) hyaline with very faint brownish tinge; veins brown; pterostigma and adjacent marking very dark brown. Abdomen with dark terminal structures.

MORPHOLOGY: Length of body: 2.0 mm. Median epicranial suture fine; anterior arms faintly discernible. Antennae fine. Length of flagellar segments: f_1:0.72 mm.; f_2:0.76 mm. Eyes moderately large but not reaching level of vertex. IO/D (Badonnel): 2.1; PO:



FIGURES 70-74. — *Copostigma (Clematostigma) latimentula* sp. n. 70.♂forewing, 71.♂epiproct, 72.♂ paraproct, 73.♂hypandrium, 74.♂phallosome.

0.87. Measurements of hind leg: F: 0.56 mm.; T: 1.08 mm.; t_1:0.308 mm.; t_2:0.168 mm.; rt:1.8:1; ct: 17, 4. Tibiae a little broadened towards distal end. Fore wing length: 3.3 mm.; fore wing width: 1.2 mm. Sc well developed, ending free in costal cell, curving neither forward nor backward. Pterostigma long and narrow with only slight hind angle from which arises a short spur-vein. First and second sections of Cu_{1a} at a distinct angle to one another. Veins and margin glabrous. Hind wing length: 2.5 mm.; hind wing width: 0.8 mm. Sc well developed, fusing with C distally. Veins and margin glabrous except for one or few fine setae near wing apex. Epiproct (fig. 76) of peculiar form, with two erect, lightly-sclerotized lobes arising at base. Paraproct (fig. 77). Hypandrium (fig. 78) curved upwards distally to form a bowl-like structure in which lies the phallosome. Phallosome (fig. 79) with parameres basally separate but joined by a thin membrane; distally two stout hook-like extensions of the parameres curve strongly upwards.

FEMALE

COLORATION: (in alcohol). Similar to make but labrum paler laterally. Fore wing (fig. 80) hyaline with a few brown marks. Hind wing (fig. 81).

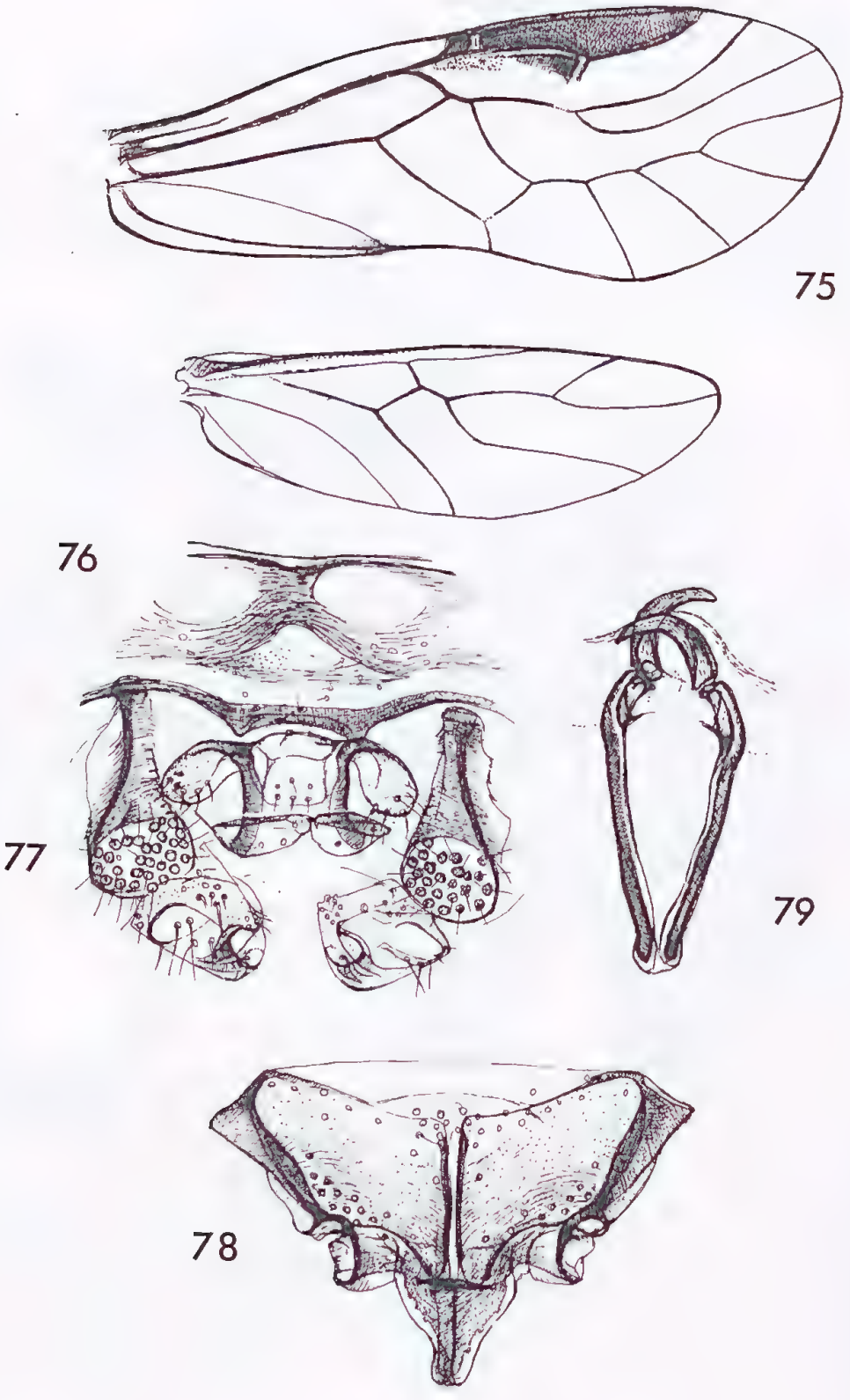
MORPHOLOGY: Length of body: 3.2 mm. Median epicranial suture distinct but anterior arms not easily discerned although their position is well marked by a dark line. Lengths of antennal segments: f_1:0.76 mm.; f_2:0.72 mm. Eyes fairly large. IO/D (Badonnel): 2.2; PO: 0.77. Anterior ocellus smaller than lateral ocelli. Measurements of hind leg: F: 0.56 mm.; T: 1.24 mm.; t_1:0.308 mm.; t_2:0.196 mm.; rt: 1.6:1; ct: 18, 2. Fore wing length: 4.0 mm.; fore wing width: 1.4 mm.; venation as in figure 80. Hind wing glabrous except for a few very small, fine setae on margin at apex. Subgenital plate (fig. 82). Epiproct (fig. 83) with very strongly sclerotized lateral bars. Paraprocts (fig. 83) mostly well sclerotized with a ventral, lightly sclerotized, setose area; trichobothrial field large, almost circular, the "rosette" bases to the setae rather small and not always in contact with neighbouring "rosettes". Gonapophyses (fig. 84) with dorsal and external valves bilobed, external valve with inner lobe extended backwards on dorsal side into a tapering but blunt-ended lobe; dorsal and ventral valves both spiculate apically. Sclerotization of entrance to spermatheca (fig. 85).

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♂, (holotype), 22.iii.1974 (C.N.S., A.S.S.); 1 ♀ (allotype) 10.vii.1975 (C.N.S., A.S.S.); Paratype: 1 ♀ , 17.iv.1975 (C.N.S.) (AM).

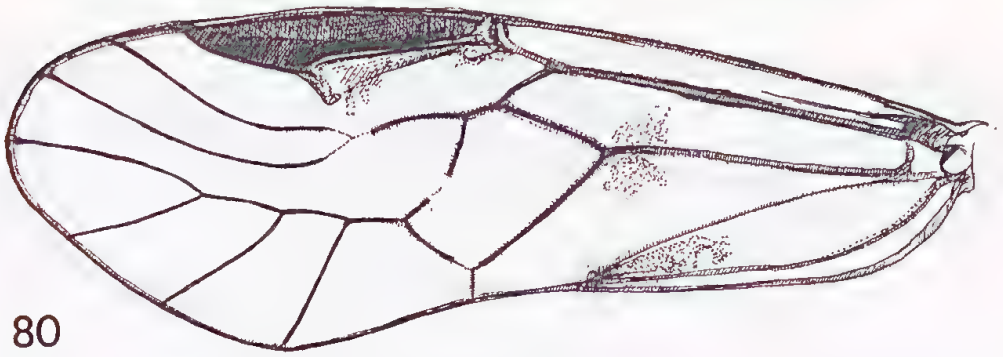
Holotype, allotype and paratype in the Australian Museum.

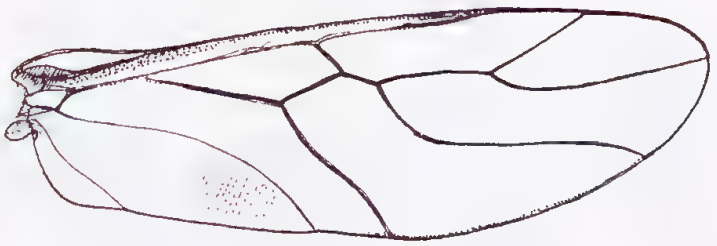
DISCUSSION: Both sexes of *Copostigma (Clematostigma) paula* can be distinguished from *C. maculiceps* Enderlein and *C. vinctum* (Enderlein) by the slightly angled hind margin of the pterostigma. It differs from *Clematostigma dubium* New (female only known) in the extent of wing markings and sclerotization of the subgenital plate; from *Clematostigma edwardsi* New (males only known) in the form of the hypandrium and from *Clematostigma inglewoodense* New (female only known) in wing pattern. The only species which it resembles in colour pattern and genitalia in both sexes is *Clematostigma tardipes* Edwards but it is much smaller and there are differences in hypandrial structure. From *Psocidus notialis* Smithers, which may be congeneric with it, it is distinguishable by the form of the apex of the parameres and the hypandrium in the male and the subgenital plate in the female; it is also larger than *C. paula.*

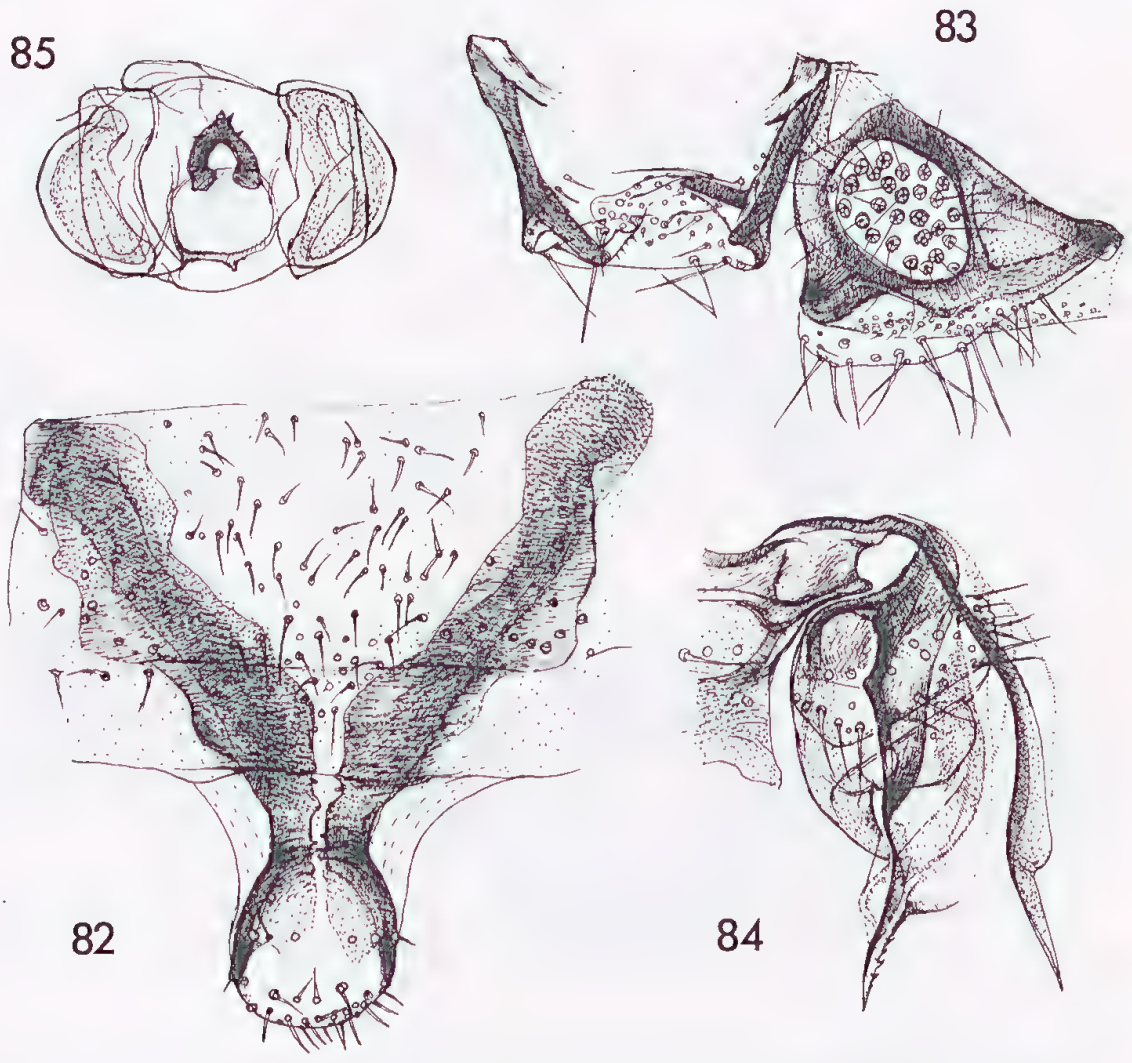
This species is referred to the genus *Copostigma* Enderlein. Enderlein (1903) erected the genus *Copostigma* with *C. dorsopunctatum* Enderlein as type species. This species has a cross-vein between Rs and M. Enderlein (1906) later erected *Clematostigma* with *Copostigma maculiceps* Enderlein as type species for those species of *Copostigma* in which Rs and M are fused for a length. Roesler (1944) regarded *Clematostigma* as a



FIGURES 75-79. — *Copostigma (Clematostigma) paula* sp. n. 75. ♂ forewing and hindwing, 76.♂ epiproct, 77.♂ paraproct, 78.♂ hypandrium, 79.♂ phallosome.







FIGURES 80-85 — *Copostigma (Clematostigma) paula* sp. n. 80. ♀ forewing, 81. ♀ hindwing, 82. ♀ subgenital plate, 83. ♀ epiproct and paraproct, 84. ♀ gonapophyses, 85. ♀ sclerification of spermathecal entrance.

subgenus of *Copostigma* and this is the arrangement adopted here as it is known that the Rs-M relationship alone is not reliable as a generic character. New (1974) has, however, accepted *Clematostigma* as of generic status when describing *C. dubium, C. edwardsi* and *C. inglewoodense*. When these and other related genera are studied a reallocation of species may be necessary.

Ptycta muogamarra sp.n.

MALE

COLORATION: (in alcohol). Head brown with dark brown markings. A double row of spots adjacent to compound eyes, across back of head and along either side of median epicranial suture; a mark along anterior arms and a spot on each side of the frons; a triangular spot anterior to ocellar triangle. Base of antenna surrounded by a narrow brown ring. Postclypeus with parallel stripes. Labrum pale laterally, darker medially. Antennae brown. Eyes black. Ocelli ringed in black. Maxillary palps pale, fourth segment black. Mesonotum dark brown; sutures, median antedorsal stripe and posterolateral edges of lateral lobes paler. Legs pale, tarsi brown. Fore wings (fig. 86) hyaline, very faintly tinged with brown; pterostigma dark brown; veins brown. Abdomen pale, apex very dark.

MORPHOLOGY: Length of body: 2.2 mm. Median epicranial suture distinct, anterior arms evanescent but position marked by dark line. Lengths of antennal segments: f_1:0.574 mm.; f_2:0.530 mm. Eyes fairly large, reaching a little above vertex. IO/D (Badonnel): 1.8; PO: 1.0. Ocelli large. Measurements of hind leg: F: 0.52 mm.; T: 0.10 mm.; t_1:0.336 mm.; t_2:0.140 mm.; rt: 2.4:1; ct: 21, 3. Fore wing length: 3.4 mm.; fore wing width: 1.2 mm. Fore wing (fig. 86) with Sc ending free in costal cell; pterostigma elongate with only slight posterior angle. Rs and M meeting in a point or fused for a short length; stem of Rs short in relation to fork. Basal section of Cu_{1a} almost in line with second but a little sinuous; long fusion of Cu_{1a} with M. Hind wing length: 2.5 mm.; hind wing width: 0.8 mm.; Rs and M fused for a length; Sc approaching costal margin. A few very small, fine setae on wing margin at apex. Ninth tergite forms a well sclerotized band. Epiproct (fig. 87). Paraproct (fig. 88). Hypandrium (fig. 89) with a broad, median, upcurved strap-like sclerotization and two lateral, posterior sclerotized extensions. Phallosome (fig. 90) closed proximally, with a strongly upcurved, narrow process posteriorly.

FEMALE

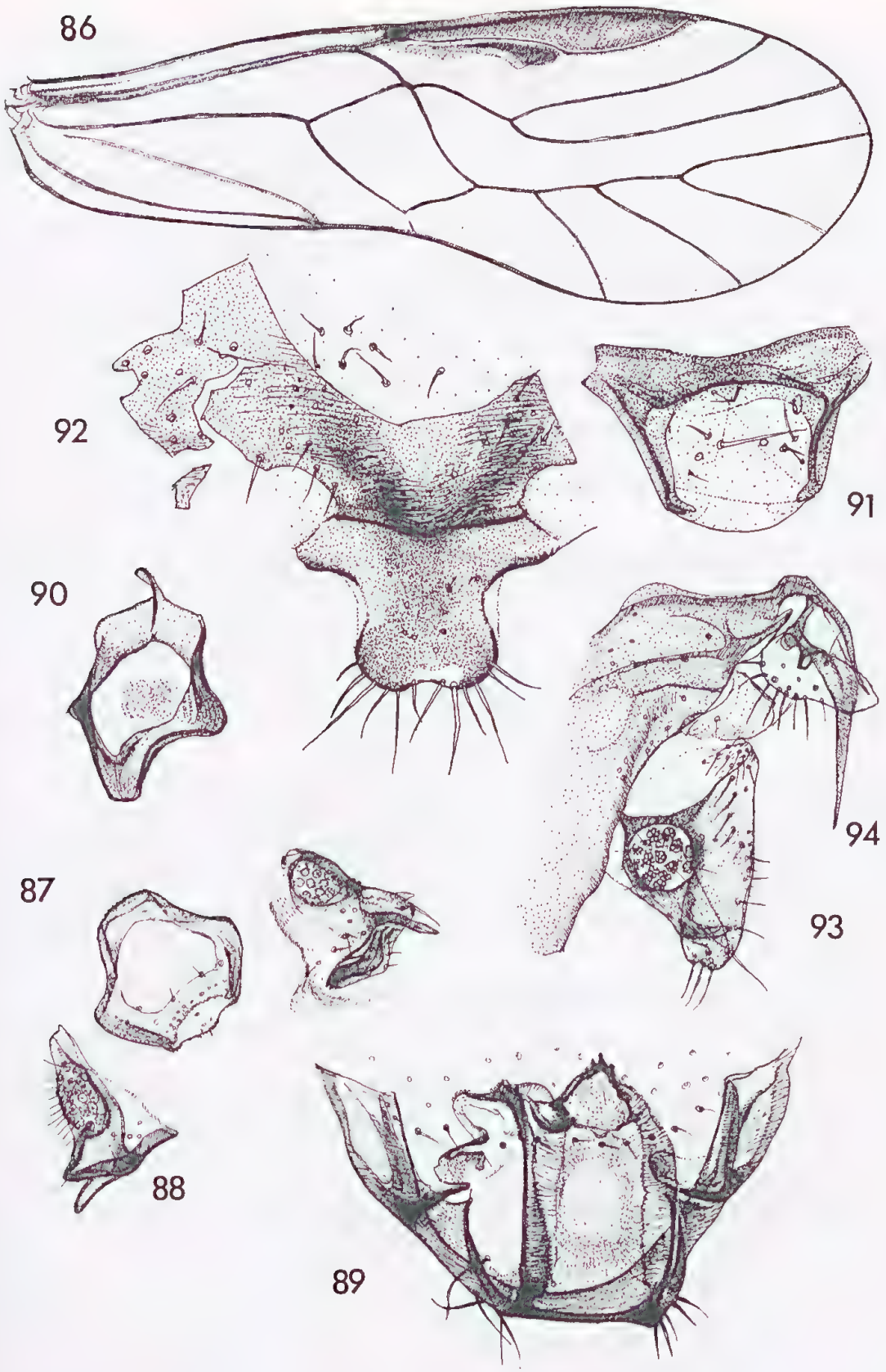
COLORATION: (in alcohol). As in male; the female also has the small spot on each side of the frons.

MORPHOLOGY: Length of body: 2.5 mm. Lengths of flagellar segments: f_1:0.462 mm.; f_2:0.448 mm. Eyes fairly small. IO/D (Badonnel): 1.8; PO: 0.87. Measurements of hind legs: F: 0.44 mm.; T: 0.96 mm.; t_1:0.266 mm.; t_2:0.126 mm.; rt: 2.1:1; ct: 20, 3. Fore wing length: 2.9 mm.; fore wing width: 0.9 mm. Venation as in male. Epiproct (fig. 91). Subgenital plate (fig. 92). Paraproct (fig. 93). Gonapophyses (fig. 94).

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 2 ♂ (including holotype), 3.iii.1975 (C.N.S., A.S.S.); 2 ♀ (including allotype), 15.xi.1973 (C.N.S., A.S.S.); Paratypes: 1 ♂ , 17.iv.1975 (C.N.S.); 1 ♀ , 2.v.1975 (C.N.S., A.S.S.); 1 ♀ , 10.vii.1975 (C.N.S., A.S.S.); 1 ♀ , 22.iii.1974 (C.N.S., A.S.S.) (AM).

Holotypes, allotype and paratypes in the Australian Museum.

DISCUSSION: *Ptycta muogamarra* differs from the other species placed in this genus by New (1974) except *cornigera* New in lacking marking adjacent to M + Cu. From *P.*



FIGURES 86-94. — *Ptycta muogamarra* sp. n. 86.♂forewing, 87.♂epiproct, 88.♂paraproct, 89. ♂hypandrium, 90.♂phallosome, 91.♀ epiproct, 92.♀ subgenital plate, 93.♀ paraproct, 94.♀ gonapophyses.

cornigera (males only known) it differs in the form of the phallosome and hypandrium. Wing length of paratypes: ♂♂ : 3.4, 3.1, 3.0 mm; ♀♀ : 2.9, 2.9, 3.0 mm.

Sigmatoneura formosa (Banks)

Amphigerontia formosa Banks 1918. *Bull. Mus. comp. Zool. Harv.* 62:4, pl. II.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 2 ♀ , 15.xi.1973 (C.N.S., A.S.S.); 1 ♂ , 18.iv.1974 (C.N.S.); 1 ♂ , 2.v.1974 (C.N.S., A.S.S.); 1 ♂ , 7 ♀ , 23.v.1974 (C.N.S.); 1 nymph, 20.vi.1974 (C.N.S., A.S.S.); 1 ♂ , 18.vii.1974 (C.N.S., A.S.S.) (AM). (Note: — This material has already been listed (Smithers 1976) in a paper on the nomenclature of this species. It is repeated here for convenience when discussing habitat preferences elsewhere in this paper).

Trichadenotecnum enderleini (Roesler)

Psocus conspurcatus Enderlein 1903. *Ann. hist. – nat. Mus. hung.* 1:224, taf. IV, fig. 13. (nec. Rambur)

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♂, 2 ♀ , 1 nymph, 18.x.1973 (C.N.S., A.S.S.); 1 ♂ , 15.xi.1973 (C.N.S., A.S.S.) 2 ♂ , 1 ♀ , 7 nymphs, 13.xii.1973 (C.N.S., A.S.S.); 1 nymph, 16.i.1974 (C.N.S., H.G.S.); 1 ♀ , 28.ii.1974 (C.N.S., A.S.S.); 1 ♀, 21.xi.1974 (C.N.S.) (AM).

MYOPSOCIDAE

Phlotodes australis (Brauer)

Psocus australis Brauer 1865. *Ver. zool. – bot. Ges. Wien* 15:908.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1♂ , 1.xi.1973 (C.N.S.); 1♂ , 2 ♀ , 2 nymphs, 15.xi.1973 (C.N.S., A.S.S.); 1 ♀ , 16.i.1974 (C.N.S., H.G.S.); 1 ♂ , 30.i.1974 (C.N.S., A.S.S.); 1 ♀ , 5 nymphs, 22.iii.1974 (C.N.S., A.S.S.); 5 nymphs, 4.iv.1974 (C.N.S., A.S.S.); 1 ♀ , 18.iv.1974 (C.N.S.); 1 ♀ , 18.vii.1974 (C.N.S., A.S.S.) (AM).

Phlotodes furcatus (Smithers)

Myopsocus furcatus Smithers 1964. *Proc. R. ent. Soc. Lond.* (B) 33:137-138, figs. 1, 2, 7.

MATERIAL EXAMINED: Muogamarra Nature Reserve, N.S.W. 1 ♀ , 1.xi.1973 (C.N.S.); 1♂ , 15.xi.1973 (C.N.S., A.S.S.); 1 ♀ , 16.i.1974 (C.N.S., A.S.S.) (AM).

HABITAT COLLECTIONS OF PSOCOPTERA IN MUOGAMARRA NATURE RESERVE

Within Muogamarra Nature reserve eight distinct habitats were chosen from which Psocoptera were periodically collected; these were in or near Peat's Crater. Peat's Crater is a somewhat circular, crater-like area of steep sandstone slopes, the bottom of the crater being formed by a diatreme of volcanic breccia covered with recent sediments. The crater has an area at base of approximately 12 hectares. It is drained by a series of streams which combine before flowing through a narrow gap in the western wall. Beyond the crater the stream flows across a flat, sedimentary area over a second small diatreme, bounded on the north and south by sandstone slopes, to a tidal channel leading to an inlet on Berowra Water, which is part of the Hawkesbury River system. The walls of the

crater and adjacent sandstone country are typically clothed with dry sclerophyll forest. The floor of the crater is covered with grassland which has been grazed by cattle; patches of bracken *(Pteridium esculentum)* occur in the grassland and groups or isolated specimens of *Acacia floribunda* of various ages occur near the drainage streams. A row of *Maclura pomifera,* which once formed a hedge, occurs across the crater floor and isolated specimens of this and weed species, e.g., blackberry, occur in the grassland area.

The habitats selected for sampling were:

1. A stand of *Casuarina glauca* Sieb. ex Spreng (fig. 95a) growing behind the tidal channel and through which flowed the stream from the crater.
2. A dense stand of bracken *(Pteridium esculentum* (Forst. f.) Cockayne) (fig. 95b). This was bounded in the north by an area of periodically boggy grassland between it and the drainage stream.
3. A mixed stand of *Casuarina littoralis* Salisb. and *C. torulosa* Ait. (fig. 95c). This was situated on the southern side of the crater floor where it meets the bottom of the sandstone slope.
4. A stand of *Acacia floribunda* (Vent.) Wild. (fig. 95d) which grew on slightly higher ground along the streamside.
5. A small patch of depauperate rainforest (fig. 96a) in the narrow gully where the stream draining the crater breaks through the rim. Although referred to here as "rainforest" this small isolated patch of vegetation can more truly be described as a patch of vegetation consisting of a few species normally found in temperate rainforest but not in sclerophyll forest.
6. A hedge of mature specimens of *Maclura pomifera* (Raf.) Schneid. (fig. 96b). This consists of a row of trees across the crater floor from near its southern margin almost to the drainage stream which at this point is more or less in the middle of the crater floor.
7. *Eucalyptus* spp. (fig. 96c) forming the upper storey on a sandstone ridge to the southeast of the crater.
8. Low, mixed, shrubby vegetation on the same ridge forming the lower storey below the eucalypt layer (fig. 96c). This is referred to in this paper as the shrub layer.

METHODS

Approximately fifteen minutes were spent collecting, by beating, in each habitat on each occasion. Collections from a habitat can be considered comparable but owing to the differences in physiognomy of the habitats and the fact that some habitats were of mixed plant species whereas others were pure stands, strict quantitative comparison between population levels is not warranted. An exception is the case of the two areas of *Casuarina* where, although of different species, general form and accessibility for beating were similar.

The first of the twenty-three collections was made on 18th October 1973, and the last on 21st November, 1974; this represents 5¾ hours collecting in each habitat between the two dates. All of the material discussed here, except the three specimens of *Copostigma (C.) latimentula,* the holotype and some paratypes of *Ptycta muogamarra* and allotype and paratype material of *C. (C.) paula* was collected between the dates given above; *C. (C.) latimentula* was taken once only during a casual collection in the area on 17.iv.1975, and

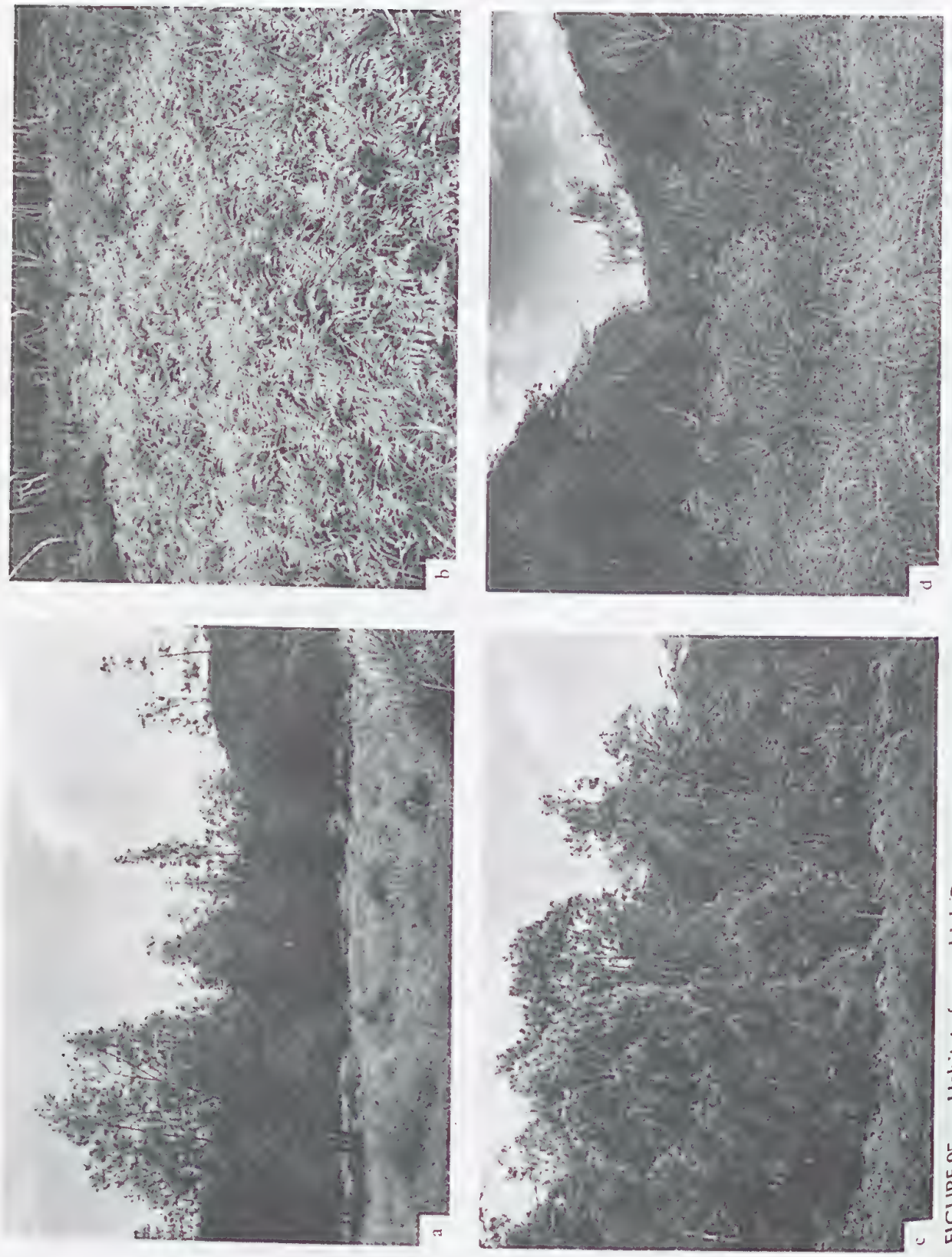


FIGURE 95. — Habitats from which Psocoptera were collected. a. *Casuarina glauca*, b. *Pteridium esculentum* (bracken), c. *Casuarina littoralis* – *C. torulosa*. d. *Acacia floribunda*.

FIGURE 96. — Habitats from which Psocoptera were collected. a. Rainforest, b. *Maclura pomifera,* c. *Eucalyptus* spp. (upper storey) and shrub layer (lower storey).

C. (C.) paula was taken on 10.vii.1975 and 17.iv.1975; *P. muogamarra* was taken on 3.iii.1975, 17.iv.1975, 2.v.1975 and 10.vii.1975. A few unidentifiable nymphs are ignored in the discussions.

DISCUSSION

Original data sheets of details of the specimens taken from each habitat on each occasion are deposited in the Australian Museum; appropriate summaries of the data only can be included in this paper.

Table I lists the species and gives the total number of specimens taken from each habitat and the number of days on which each species was taken. Table II gives a summary of the number of specimens and number of species (in brackets) taken from each habitat on each occasion.

In all, forty-three species of Psocoptera were taken in Muogamarra Nature Reserve, of which sixteen were undescribed. Fifteen of these have been described in this paper.

The two habitats consisting of *Casuarina* species have much in common although clearly *C. glauca* is less favoured than the other species. The *Eucalyptus, C. littoralis, C. torulosa* and the shrub layer make up what is generally regarded as vegetation cover typical of the Hawkesbury sandstone environment and it will sometimes be useful to discuss these habitats together.

The richest habitats were the mixed stand of *Casuarina littoralis* and *C. torulosa* (twenty-two species) and the rainforest (nineteen species) with specimens being more abundant in the rainforest. Bracken (six species), *Acacia floribunda* (six species) and *Casuarina glauca* (nine species) were the poorest in terms of species but both bracken (fifty specimens) and *C. glauca* (sixty-one specimens) have fairly high populations of their few species but *Acacia floribunda* is clearly an unsuitable habitat for Psocoptera in general as only seven specimens were taken from it.

These species numbers and population levels are consistent with experience gained during general collecting in the Australian environment. Dense populations which are sometimes met with in African and European situations are seldom encountered here. Nevertheless, there is little doubt that the Psocoptera are the major intermediary through which much of the resources bound up in the microflora are made available to other organisms.

Many species (twenty-two) were taken on less than five occasions and some of these (nine species) were represented by only one specimen. Little can be said about habitat preferences when a species is taken on so few occasions; on the other hand, specimens of one species taken singly from several habitats suggest little specificity in habitat requirement even though populations may be quite low. It may be noted that unexpectedly small numbers were taken on 16th January, 1974. This collection was made following a lengthy period of rain and this probably accounts for several of the habitats yielding no specimens at all.

With these points in mind and with general observations of the microhabit occupied by some of the species some useful discussion of this collection data is possible. As mentioned in the introduction to this paper one of the objects of the work was to make preliminary observations on which future, more detailed work could be planned. The comments which follow should be considered as preliminary in nature.

Table I. List of species, total specimens from each habitat and number of days on which each species was taken.

Species	*C. glauca*	*C. littoralis* *C. torulosa*	Shrub layer	*Eucalyptus*	Bracken	Rainforest	*M. pomifera*	*A. floribunda*	Occasions collected	Total specimens
Echmepteryx brunnea		3	3	7			1		9	14
E. picta				1					1	1
Caecilius macrostigma		1				3	1		4	5
C. lineatus	19	49			3	1			17	72
C. pteridii		3	4		12	1		2	12	22
Paracaecilius hylobius						7			6	7
Enderleinella globiclypeus		1				2			2	3
Caeciliid sp			1						1	1
Taeniostigma trickettae						69			19	69
Ectopsocus californicus			1	2	1	21	6		12	31
E. punctatus		1							1	1
E. perplexus		10							3	10
E. pteridii			2		7				4	9
E. parmatus		1							1	1
E. russulus		2							1	2
E. albiceps						5			2	5
Peripsocus milleri	1	3				1	1	1	5	7
P. maoricus		3					83		7	86
P. tillyardi	5	8	9		2	4	1		9	29
P. hamiltonae						3			2	3
P. roseus						6	2		4	8
Pseudocaecilius lachlani			4	7			16	1	13	28
Heterocaecilius brunellus			76						15	76
Lobocaecilius monicus						16			7	16
Pseudoscottiella tanei				1					1	1
Aaroniella rawlingsi			2	1					3	3
Austropsocus viridis						11			8	11

Table I. List of species, total specimens from each habitat and number of days on which each species was taken.

Species	*C. glauca*	*C. littoralis* *C. torulosa*	Shrub layer	*Eucalyptus*	Bracken	Rainforest	*M. pomifera*	*A. floribunda*	Occasions collected	Total specimens
Austropsocus tibialis		4			25	2			13	31
Haplophallus ornatus	3					4	4		5	11
H. sinus		6	3	1		1	2	1	8	14
H. guttatus			11				1		6	12
Spilopsocus ruidis						1			1	1
Paedomorpha gayi		1		2					2	3
Blaste tillyardi	7	1					1		5	9
B. taylori		1	1						1	2
B. michaelseni				1					1	1
Copostigma latimentula			3						1	3
C. paula			1						1	1
Ptycta muogamarra	1	2							2	3
Sigmatoneura formosa	9	1					3	1	6	14
Trichadenotecnum enderleini		1					17		6	18
Phlotodes australis	15	1		1		6	16	1	8	40
P. furcatus	1	2							3	3
Total species	9	22	13	10	6	19	15	6		42
Total specimens	61	105	118	24	50	164	155	7		684

23 spp.
166 specs.

33 spp.
247 spec.

Table II. Number of specimens and number of species (in brackets) taken from each habitat on each occasion.

Date	*C. glauca*	*C. littoralis* – *C. torulosa*	Shrub layer	*Eucalyptus*	Bracken	Rainforest	*M. pomifera*	*Acacia floribunda*
18/10/73	4 (2)	15 (7)			8 (4)		21 (4)	
1/11/73	12 (4)	16 (8)	7 (2)		2 (1)	23 (7)	39 (5)	
15/11/73	24 (3)	20 (6)	1 (1)		3 (2)	16 (7)	33 (5)	
29/11/73		2 (2)			4 (1)	5 (3)	7 (3)	2 (2)
13/12/73		8 (2)	4 (2)	1 (1)	6 (2)	6 (6)	23 (3)	
16/1/74	2 (2)	8 (1)					1 (1)	
30/1/74		6 (4)	2 (1)			10 (2)	1 (1)	2 (2)
28/2/74		7 (1)			2 (1)	4 (2)	3 (3)	
22/3/74	3 (3)	3 (2)	1 (1)	2 (1)	1 (1)	3 (1)	19 (2)	
4/4/74		6 (4)	2 (1)	3 (2)		14 (7)		
18/4/74	3 (2)		6 (3)			3 (2)	2 (2)	2 (2)
2/5/74	2 (2)		9 (5)		5 (2)	11 (4)		
23/5/74	8 (1)	1 (1)	17 (8)		2 (1)	6 (3)		
20/6/74		3 (2)	16 (3)			12 (3)		
9/7/74			6 (2)	2 (2)		3 (2)		
18/7/74	1 (1)		7 (1)	8 (6)		5 (1)		1 (1)
1/8/74	1 (1)	1 (1)	8 (2)	2 (2)	2 (1)	10 (5)		
22/8/74		1 (1)	2 (1)		1 (1)	6 (3)	5 (3)	
19/9/74	1 (1)	1 (1)	12 (4)	5 (3)	5 (2)	7 (4)		
3/10/74		1 (1)			2 (2)	4 (1)		
22/10/74		1 (1)	10 (1)	1 (1)	2 (1)	3 (2)		
7/11/74		5 (3)	3 (2)		4 (2)	11 (4)		
21/11/74			5 (1)		1 (1)	2 (1)	1 (1)	

COMMENTS ON HABITATS

CASUARINA GLAUCA

Nine species were found on *Casuarina glauca*, all of which were taken from other habitats. Psocoptera were somewhat more numerous in October and November, 1973 with fewer being taken from late November onwards (fig. 97); populations showed no rise to comparable levels in October-November 1974; in fact, none was taken from *C. glauca* after September 1974. The dominant species were *Caecilius lineatus* and *Blaste tillyardi*. The former is mainly an inhabitant of the distal branchlets and the latter is a bark dweller. Of a total of seventy two specimens of *Caecilius lineatus* taken during the survey all but four were taken from *C. glauca* or the other *Casuarina* habitat. *Peripsocus tillyardi* was also taken from this habitat; it also occurred in all the other habitats except *Eucalyptus* and *Acacia floribunda*. *Phlotodes australis* and *Sigmatoneura formosa*, although taken in some numbers, were each taken on only two occasions from *C. glauca*. Both species have the habit of congregating into groups during the nymphal stages after which they disperse. This habit would account for the capture of specimens in isolated batches.

CASUARINA LITTORALIS AND *C. TORULOSA*

Twenty-two species were taken from this habitat; all except one of the species taken from *C. glauca (Haplophallus ornatus)* were taken also from this habitat. As in the case of *C. glauca* the October-November, 1973 collections yielded more specimens than later with the period from mid-April to late October yielding few (fig. 97); again, populations did not return to 1973 levels in October-November, 1974. The dominant species was, as in *C. glauca, Caecilius lineatus*. *Ectopsocus perplexus* (ten specimens) was taken on three occasions only, but as all were from this habitat there is a possibility that it may prefer *Casuarina* to other habitats. Numbers were, however, too low for a definite statement on this point. *Ptycta muogamarra* and *Phlotodes furcatus* were also taken in small numbers from the two *Casuarina* habitats only; they may well prefer these hosts. In general, the psocopteran fauna of the *C. littoralis* and *C. torulosa* habitat is similar to that of *C. glauca* but with a greater number of species occurring in small numbers on the former, several of which were taken only from this habitat. The proximity of the *C. glauca* stand to the tidal area with a somewhat salt-laden atmosphere may account for the fewer species there.

SHRUB LAYER

The sandstone flora shrub layer in reasonably rich is species with two dominants, i.e., *Heterocaecilius brunellus* and *Haplophallus guttatus*. *H. brunellus* was taken only in this habitat and of *Haplophallus guttatus* only one specimen was taken elsewhere (on *Maclura pomifera*). Several species were taken only from the shrub layer but as one or two of each were collected nothing can be said concerning their habitat preferences. The two dominant species, which made up the bulk of specimens from this habitat, were distinctly more abundant during the colder part of the year (fig.97); several of the species of which few specimens were taken occurred during this period. Figure 98 shows the collection cumulative totals of species taken through the survey from the shrub layer. This shows a distinct increase in the rate of appearance of species taken for the first time during April and May (cf. fig. 98 for similar data for the *Casuarina littoralis – C. torulosa* habitat). The psocopteran fauna of the shrub layer seems to be cool-climate adapted and one is tempted to postulate a close association with the strongly endemic sandstone flora; indeed, *Haplophallus* is a genus of southern origin and belongs to a family (Philotarsidae) which has its greatest development and proliferation of species in Australasia and New Caledonia.

EUCALYPTUS SPP.

Eucalyptus spp. yielded ten species of Psocoptera. Of these only one *(Pseudoscottiella tanei)* is possibly a green leaf dweller. One *(Ectopsocus californicus)* is a dried leaf inhabitant but, in all, only three specimens were taken of these two species. The remaining species are all bark dwellers. Little general comment can be made about the *Eucalyptus* psocopteran fauna except to indicate its sparse nature and the preference of species which do occur on it for the parts of the plant other than the green living leaves. No specimens of the families Caeciliidae nor Peripsocidae were taken from the *Eucalyptus* habitat and only a single specimen of the family Psocidae was taken. The Pseudocaeciliidae, Lepidopsocidae and Philotarsidae made up the bulk of the material taken.

PTERIDIUM ESCULENTUM (Bracken)

Only six species were taken from bracken but fifty specimens were collected. Half of these were *Austropsocus tibialis,* which was taken elsewhere only from the *C. littoralis – C. torulosa* habitat and the rainforest in small numbers. This is clearly a species with a preference for bracken fronds. *Caecilius pteridii* was taken mostly from bracken during the spring being absent from bracken during the rest of the year. In general, Psocoptera were more numerous on bracken during spring and summer (fig. 97). Psocidae, Pseudocaeciliidae and Lepidopsocidae were not taken from bracken.

RAINFOREST

Rainforest yielded nearly as many species as the *C. littoralis – C. torulosa* association and provided far more specimens than any of the other habitats. This is clearly the most suitable habitat, in general, for Psocoptera. Seven species were found only in the rainforest, four of them being taken on more than five occasions. *Paracaecilius hylobius, Taeniostigma trickettae, Lobocaecilius monicus* and *Austropsocus viridis* are probably restricted to the rainforest type habitat. *T. trickettae* was a very common species. *Ectopsocus albiceps* and *Spilopsocus ruidis* are also probably restricted to the rainforest habitat; although numbers taken in the present survey were low, there is evidence from other casual collecting that they are so restricted. As might be expected from a habitat with relatively less variable seasonal conditions there was little indication of seasonal preferences nor of gross population fluctuations (fig. 97). It is interesting to note that of the eight species of the family Psocidae collected in the present survey not one was taken from the rainforest habitat.

MACLURA POMIFERA

Although fifteen species were taken from *Maclura pomifera* only three were common, namely, *Peripsocus maoricus, Pseudocaecilius lachlani* and *Trichadenotecnum enderleini* (sixteen specimens of *Phlotodes australis* were taken from *M. pomifera* but all were taken on the one occasion). *Maclura pomifera* is a deciduous plant, losing its leaves (in Muogamarra Nature Reserve) in late April-early May. The commonest species, listed above, in this habitat are all mainly bark dwellers, as are most of the species taken in smaller numbers from this habitat. It is remarkable, therefore, that at the time of leaf fall the entire psocopteran fauna virtually disappeared from the trees and only eight specimens were taken after early April, 1974 out of a total of one hundred and fifty-five from this habitat (fig. 97). This sudden disappearance was quite dramatic; the presence of leaves appears essential for the bark inhabiting Psocoptera in this habitat. The apparently anomalously large number of specimens taken on 22nd March, 1974 is accounted for by the capture of many nymphs of *Phlotodes australis,* a species in which the nymphs congregated in groups.

ACACIA FLORIBUNDA

Only seven specimens were taken from *Acacia floribunda*, belonging to six species. None was restricted to this habitat and all were taken from at least three other habitats. *Acacia floribunda* is clearly unsuitable for Psocoptera in general but is occasionally inhabited by species of wide habitat tolerance. Leaf cover is sparse in this species, all other habitats sampled were more leafy and more shady. In this connection it is, perhaps, significant that the Psocoptera on *M. pomifera* disappeared at leaf fall.

One general comment on overall population levels of Psocoptera may be made. The *Casuarina* habitats supported greater populations in October-November than at other times. The shrub layer of the sandstone flora supported its greatest population from April to July and the rainforest population, although fluctuating from sample to sample, showed little overall seasonal variation.

COMMENTS ON SPECIES

LEPIDOPSOCIDAE

Echmepteryx brunnea was taken from the shrub layer habitat, *C. littoralis – C. torulosa* (but not *C. glauca*) and from *Eucalyptus*. A single female was taken from *M. pomifera*. It is essentially a species of the true sandstone flora; adults were taken from November to September but were not common at any time.

CAECILIIDAE

Caecilius lineatus was taken mainly from the three *Casuarina* species, only four specimens out of seventy-two were taken from other habitats (three from bracken, one from rainforest). Although common from September to April very few specimens were taken during May, June, July or August. *C. lineatus* was the dominant psocopteran on *Casuarina* spp.

Caecilius pteridii was taken from all habitats, except *C. glauca, M. pomifera* and *Eucalyptus*. From September to December specimens were taken mainly from bracken. None was taken from January to early April nor from June to August. The few autumn specimens which were taken were from the sandstone flora shrub layer (with one on *Acacia floribunda*) and these were all taken during late April to late May. This suggests that this species has a strong association with bracken and spends the warmer months there, moving to the shrub layer of the sandstone flora during the colder periods of the year.

Paracaecilius hylobius was taken from rainforest only and is clearly a species preferring, perhaps restricted to, that habitat.

STENOPSOCIDAE

Taeniostigma trickettae is clearly a rainforest species. It was the dominant one taken from that habitat and was taken nowhere else.

ECTOPSOCIDAE

Ectopsocus californicus is an inhabitant of dried leaves of broad-leaved plants. It was taken mainly from the rainforest habitat but was also taken from all other habitats except bracken and *Casuarina*. Many species of *Ectopsocus* are dependent on the occurrence of dead, dry leaves which are rapidly colonized at a certain stage of decomposition as opportunity arises.

Ectopsocus perplexus was taken only in small numbers from *Casuarina littoralis – C. torulosa* in spring and summer. It probably prefers these host plants.

PERIPSOCIDAE

Peripsocus maoricus was taken in large numbers from *M. pomifera* from October to mid-November, 1973. Populations declined during December 1973 after which very few specimens were taken. Apart from those taken from *M. pomifera* only three others were taken, all from *C. littoralis – C. torulosa*. *P. maoricus* appeared to be an early-season species which moves to some other habitat at other periods. Although Psocoptera in general virtually disappeared from *M. pomifera* with leaf fall in April, the disappearance of *P. maoricus* occurred much earlier, in December. Populations did not reappear the following October.

Peripsocus milleri and *P. tillyardi* were both taken from a wide range of habitats the former in small numbers; neither occurred on bracken nor *Eucalyptus*. *Peripsocus hamiltonae* was taken only from the rainforest but very few were taken. *P. roseus* was taken from rainforest (six specimens) and *M. pomifera* (two specimens).

PSEUDOCAECILIIDAE

Pseudocaecilius lachlani was taken mainly from *M. pomifera* from October to December, 1973. From April to October 1974 it was taken mainly from *Eucalyptus* with a few specimens from the shrub layer. The numbers taken suggest that it is a spring-summer species with some seasonal change of habitat.

Heterocaecilius brunellus is the dominant psocopteran of the shrub layer of the sandstone flora; it was taken in large numbers and only from that habitat. It was distinctly more abundant during the colder months of the year.

Lobocaecilius monicus was taken only from rainforest but followed, remarkably, the seasonal pattern of *Heterocaecilius brunellus* in being essentially a cold season species; it was taken mainly from March to July with only two additional specimens taken in October.

PHILOTARSIDAE

Austropsocus viridis is a bright green species taken only in rainforest and, unusual for a philotarsid, appears to be a leaf dweller. It is, apparently, confined to rainforest habitats.

Austropsocus tibialis, on the other hand, was taken mainly from bracken and with *Caecilius pteridii* made up the bulk of the specimens from that habitat. Other specimens (two) were taken from rainforest and the *Casuarina littoralis – C. torulosa* habitat.

Haplophallus ornatus and *H. sinus* both occurred in several habitats whereas *H. guttatus* was almost restricted to the shrub layer.

PSOCIDAE

Blaste tillyardi was taken from the *Casuarina* habitats and (one specimen only) from *M. pomifera.*

Trichadenotecnum enderleini was taken from *M. pomifera* in fairly large numbers with one specimen from *C. littoralis – C. torulosa*. Like *P. maoricus* it had virtually disappeared from *M. pomifera* by January.

Sigmatoneura formosa was taken from several habitats with woody stems, but not from rainforest nor *Eucalyptus*.

MYOPSOCIDAE

Phlotodes australis was taken from all habitats in small numbers but not from the shrub layer nor bracken. It is a bark inhabitant.

Phlotodes furcatus, also a bark dweller, was taken only from the *Casuarina* habitats but the small numbers involved make it impossible to generalize on its habitat preferences.

HABITAT PREFERENCES

Owing to the small numbers of specimens taken of many of the species apparent habitat preferences and restrictions of only some species can be indicated.

Caecilius lineatus, Ectopsocus perplexus and *Blaste tillyardi* all seemed to have a preference for *Casuarina* spp. *Heterocaecilius brunellus* appeared to be restricted to shrub layer of the sandstone flora habitat whilst *Haplophallus guttatus* had a strong preference for it. *Pseudocaecilius lachlani* seemed to have a winter preference for *Eucalyptus*. *Caecilius pteridii, Ectopsocus pteridii* and *Austropsocus tibialis* had a preference for bracken. *Paracaecilius hylobius, Taeniostigma trickettae, Ectopsocus albiceps, Lobocaecilius monicus* and *Austropsocus viridis* were all restricted to rainforest with *Ectopsocus californicus* having a preference for it (it should be remembered, however, that this species is an inhabitant of dried leaves). *Peripsocus maoricus* and *Trichadenotecnum enderleini* preferred *Maclura pomifera* whilst *Pseudocaecilius lachlani* had a summer preference for it. Only two habitats, therefore, had species which appear to be restricted to them, shrub layer of the sandstone flora (which had *H. brunellus)* and rainforest (which had *P. hylobius, T. trickettae, E. albiceps, L. monicus* and *A. viridis).*

ACQUISITION OF SPECIES THROUGH THE COLLECTING PERIOD

Figure 98 indicates the total number of species which had been collected from each habitat by each date. It can be expected that as the species normally occurring in a habitat are taken, the "curve" will flatten out with few additional species being recorded as collecting progresses through the season.

From *Casuarina glauca* (fig. 98) a total of nine species was collected. These had all been taken by 23 May, 1974, i.e. in about eight months, after which no further species were recorded. More than half of these had been taken at the end of one month's collecting, i.e. in three visits involving three quarters of an hour's collecting time in all. Thereafter species were added infrequently, the last four taking six months to be found and of these only a few specimens were taken. In all probability the collection includes most of the species occurring on *C. glauca*.

In the *Casuarina littoralis – C. torulosa* habitat (fig. 98) twenty two species were taken and the pattern of acquisition is much the same as in *C. glauca*. In the first five weeks fifteen species had been taken after which additional species were taken infrequently. The last species to be taken was first collected on 7th November, 1974. It is possible that a

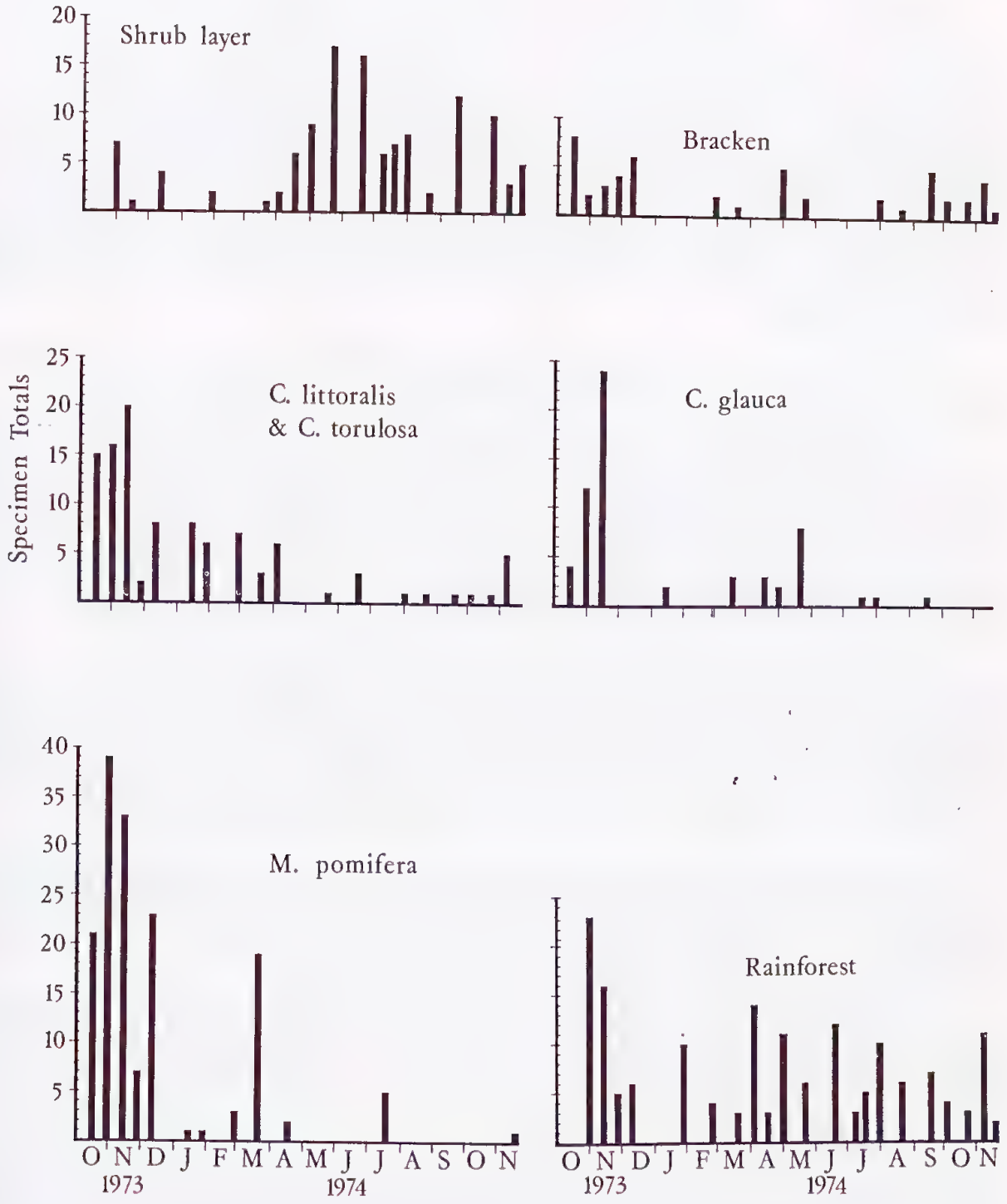


FIGURE 97. — Total number of specimens taken from bracken, *M. pomifera*, Rainforest, shrub layer, *C. littoralis* – *C. torulosa* and *C. glauca*.

few more species which were not detected might have been present in the habitat. Species taken for the first time late in the collecting period were taken only in very small numbers.

The shrub layer of the sandstone flora habitat (fig. 98) yielded thirteen species during the collecting period (another was taken during casual collecting on 17th December, 1975) but the pattern of acquistion is in contrast to that from the *Casuarina* habitats. Only three species were taken in the first month and it was another four months before a fourth was added. In the next two months, however, another seven species appeared after which it took until almost the end of the collecting period to find the last two species. There was a marked increase in the number of species appearing during the cooler part of the year. It is also interesting that those species which had been present from the beginning of the sampling period reached their highest numbers during the cooler months. Species (and populations) increased during the cooler period suggesting, again, that the fauna of the shrub layer of the sandstone flora is mainly cool-climate adapted.

In the *Eucalyptus* habitat (fig. 98) ten species were taken. Acquisition of species was slow until April 1974, as in the shrub layer but with fewer species involved.

Bracken (fig. 98) (and ferns in general) is not a rich habitat for any group of insects and Psocoptera are no exception. Only six species were taken and these were all collected in the first two months. One of the dominant species *(Austropsocus tibialis)* was taken throughout the sampling period but the other *(Caecilius pteridii)* was present on bracken during the warmer months only but appeared in the sandstone flora habitat during the cooler months. As no additional speces were taken after 29th November, 1973, it is very likely that all species occurring on bracken were recorded.

Rainforest (fig. 98) is generally accepted as a rich habitat for Psocoptera; nineteen species were taken. Almost half of these were taken in the first three occasions after which no additional species were recorded for another three and a half months. Surprisingly, additional species did appear from then on with another six being recorded over the next seven months. As one additional species was recorded as late as 7th November, 1974, it seems likely that a few species might have remained undetected in this habitat.

From *Maclura pomifera* (fig. 98) fifteen species were collected. Nine of these had been taken in the first month after which the additional species were taken in small numbers. No further species were recorded after the 22nd August, 1974, and it seems likely that from this habitat all available species were taken.

The populations on *Acacia floribunda* (fig. 98) were low in species and specimens. The habitat is clearly very unsuitable for Psocoptera. The first of the six species was not taken until the fourth collecting date (29th November, 1973) and the last on 18th July, 1974.

The data collected during this preliminary brief, single-cycle, sampling period suggests that for most habitats collecting in brief spells over a month of two during the spring or summer will suffice to yield a fair proportion (a half of more) of the species present. This, however, would be unsatisfactory for the shrub layer of the sandstone flora and *Eucalyptus* habitats which yield more species in the cooler months.

CONCLUSION

The preliminary nature of this work was pointed out in the introduction to this paper and the results have been assessed somewhat conservatively. The work has, however,

provided an inventory of the common species of Psocoptera and some interesting indications of their seasonal occurrence and preferences for the main habitats in Muogammara Nature Reserve; at the same time it has provided data on which more detailed studies of the biology and ecology of the group can be planned.

ACKNOWLEDGEMENTS

I would like to thank the Director of the National Parks and Wildlife Service for permission to work in Muogamarra Nature Reserve, Mrs. B. Hamilton and Mr. M. Tane for their help during the work, the collectors listed earlier in this paper for assistance in the field, Professor I. W. B. Thornton for determination of the Philotarsidae, the staff of the National Herbarium for plant identification, Mr. G. Millen for taking habitat photographs and Miss J. O'Regan and Mr. G. Daniels for preparing the illustrations to this paper.

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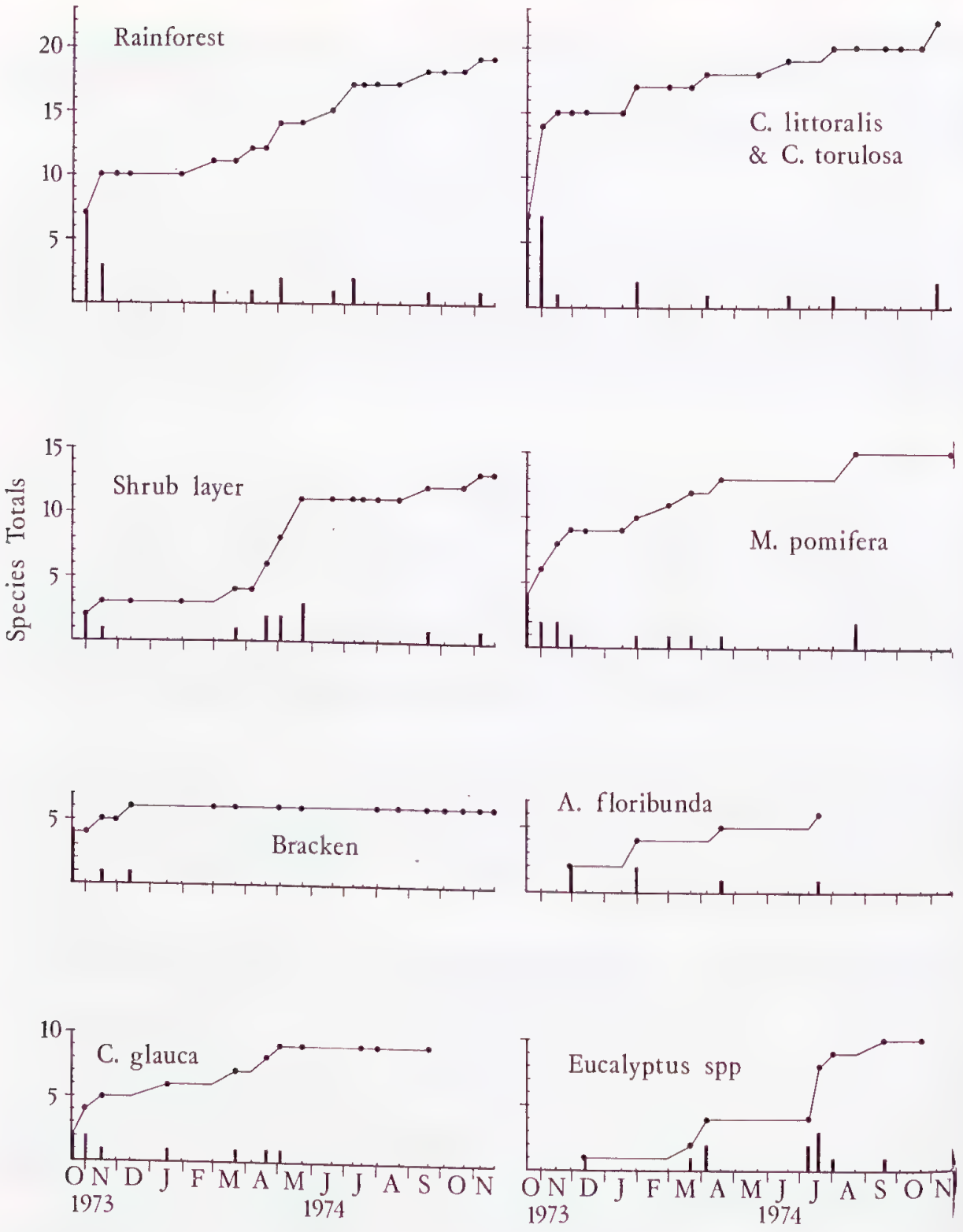

FIGURE 98. — Cumulative totals of species taken (continuous line) and number of species recorded for the first time in each habitat (bars).

NEPHTYIDAE (POLYCHAETA : ERRANTIA) FROM AUSTRALIA

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SUMMARY

The Australian Nephtyidae are represented by 13 species in four genera, *Aglaophamus* (4 species), *Inermonephtys* (1 sp.), *Micronephthys* (1 sp.) and *Nephtys* (7 spp.). Five new species are described, *Aglaophamus gippslandicus* n.sp., *A. profundus* n.sp., *Nephtys inornata* n.sp., *N. mesobranchia* n.sp., and *N. semiverrucosa* n.sp. *Nephtys vikingensis* Paxton, 1974 is synonymised with *N. longipes* Stimpson, 1856 and *Micronephthys sphaerocirrata* (Wesenberg-Lund, 1949) is recorded from Australia for the first time. Descriptions are provided for all species examined.

INTRODUCTION

Nephtyids were first recorded from Australian waters by Stimpson (1856), who briefly described *Nephtys longipes* from Botany Bay, N.S.W. By 1922 the number of recorded species had grown to four: Augener (1913) described *N. gravieri* from near Fremantle, W.A. Benham (1915, 1916) found *Aglaophamus macroura* (Schmarda) from deep water east of Bass Strait, and Augener (1922) recorded *A. dibranchis* from south-east Australia, N.S.W. No new species were found until 1963, when Fauchald described *N. mirocirris* from Spencer Gulf, S.A. and the widely-distributed *N. australiensis*. *Aglaophamus verrilli* (McIntosh) was recorded from Moreton Bay by Rullier (1965) and *Nephtys picta* Ehlers from Port Phillip Bay by Knox and Cameron (1971). In 1974, Paxton reviewed a number of these species, described *Inermonephtys palpata* from Bowen, Qld, described *Nephtys picta* Knox and Cameron as a new species, *N. vikingensis*, recorded *N. paradoxa* Malm from deep water off southern New South Wales, and synonymised *N. mirocirris* with *N. gravieri*.

Our examination of material from a number of recent studies has indicated that some mistakes remained in earlier identifications and has added further new species and records. A large amount of material has become available from ecological studies, particularly those being carried out in Moreton Bay (W. Stephenson *et al.*, Univ. Queensland), Botany Bay (N.S.W. State Fisheries), Port Hacking (CSIRO Division of Fisheries and Oceanography), Western Port and Port Phillip Bay (Western Port Environmental Study, WPES, and Port Phillip Bay Environmental Study, PPBES, Fisheries and Wildlife Divison, Victoria) and in many coastal and estuarine areas of New South Wales by the Australian Museum.

We have used this material and re-examined much of the previously-described material for this systematic account. Specimens were examined of all species except *Aglaophamus dibranchis* (Grube, 1878).

Records of The Australian Museum, 1977, **Vol. 31, No. 8,** 307-347, Figures 1-43.

The synonymy of *N. mirocirris* Fauchald and *N. gravieri* Augener suggested by Paxton (1974) is confirmed by examination of type material of *N. gravieri*. *Nephtys longipes* Stimpson, considered indeterminable by Augener (1922) and Paxton (1974), is regarded as a prior synonym of *N. vikingensis* Paxton. *Aglaophamus macroura* (Schmarda), recorded by Benham (1915, 1916) is a new species, *A. profundus* n.sp. Some confusion has existed between *N. gravieri, N. australiensis* and a third species, *N. inornata* n.sp.: no valid record now exists for *N. australiensis* in Western Australia, and some records of *N. australiensis* in New South Wales and South Australia are referred to *N. inornata n.sp. and N. gravieri* respectively. The referral of Queensland records of *N. gravieri* and *N. dibranchis* to *N. australiensis* and *Aglaophamus verrilli* respectively (Paxton, 1974) is agreed with. Three additional new species were found in our material: *Aglaophamus gippslandicus* from Bass Strait, *Nephtys mesobranchia* from Gladstone, Qld, and *N. semiverrucosa* from near Darwin. The genus *Micronephthys* is newly recorded from Australia, *M. sphaerocirrata* (Wesenberg-Lund, 1949) being found in two localities in Queensland.

In addition to the features usually considered important in the taxonomy of nephtyids, we have paid particular attention to (1) the distribution on the pharynx of the verrucae (= 'warts', prickles or tubercles of other authors), (2) the presence of supra- and subacicular lobes in some species and (3) the precise distribution along the body of the various types of setae.

The material examined is deposited with the Australian Museum, Sydney (AM), the National Museum of Victoria, Melbourne (NMV), the Queensland Museum, Brisbane (QM), the Tasmanian Museum, Hobart (TM), and the Allan Hancock Foundation, Los Angeles (AHF), the British Museum (Natural History), London (BM), and the Smithsonian Institution, Washington (USNM).

Additional material is held by the Fisheries and Wildlife Division, Victoria (Marine Pollution Studies Group).

Collecting localities indicated in the distribution diagrams (figs 41-43) have been given a numerical reference corresponding to localities indicated in the text for individual species.

KEY TO AUSTRALIAN GENERA AND SPECIES OF NEPHTYIDAE

1. Interramal cirri present 2
   Interramal cirri absent; postacicular setae include lyrate setae ..... *Micronephthys sphaerocirrata*
2. Interramal cirri curved inwardly 3
   Interramal cirri curved outwardly ..... *Nephtys* 7
3. Pharynx with papillae; one pair of antennae, one pair of palps *Aglaophamus* 4
   Pharynx without papillae; one pair of palps only .. *Inermonephtys palpata*
4. Postacicular setae include lyrate setae 5
   Lyrate setae absent 6
5. Pharynx with 14 rows of subdistal papillae and with median dorsal papilla; position of 1st interramal cirrus not known. .....*A. dibranchis* 7
   Pharynx with 22 rows of subdistal papillae, lacking median dorsal papilla; interramal cirri from setigers 7-8 ..... *A. verrilli*
6. Interramal cirri from setiger 3; pharynx with 14 rows of subdistal papillae, no median dorsal papilla ..... *A. gippslandicus* n.sp.
   Interramal cirri from setiger 7; pharynx with 22 rows of subdistal papillae; deep water ..... *A. profundus* n.sp.

7. Prostomium produced anteriorly ..... *N. longipes*
   Prostomium not produced anteriorly 8
8. Interramal cirri from setigers 8-10, with lateral foliaceous lobes *N. paradoxa*
   Interramal cirri from setigers 3-8, without foliaceous lobes 9
9. Postacicular setae of middle and posterior setigers lacking spinose setae, interramal cirri from setigers 5-8, pharynx lacking verrucae 10
   Postacicular setae include spinose setae, interramal cirri from setigers 3-4, pharynx with verrucae 11
10. Interramal cirri from setiger 5, continuing almost to pygidium; pharynx lacking median dorsal papilla ..... *N. inornata* n.sp.
    Interramal cirri from setigers 7-8, absent in posterior half of body; pharynx with median dorsal papilla ..... *N. mesobranchia* n.sp.
11. Pharynx with verrucae on proximal portion only of basal region; interramal cirri from setiger 4 ..... *N. semiverrucosa* n.sp.
    Pharynx with verrucae over entire surface of basal region 12
12. Pharynx with median dorsal subdistal papilla; interramal cirri from setiger 4 ..... *N. australiensis*
    Pharynx lacking median dorsal subdistal papilla; interramal cirri from setiger 3 ..... *N. gravieri*

SYSTEMATICS

Aglaophamus Kinberg, 1866
(*sensu* Hartman, 1950)
Aglaophamus dibranchis (Grube, 1878)

Nephthys dibranchis. — Augener, 1922 : 17-20, fig. 5; 1927 : 116-118.
— Fauvel, 1932 : 117-118 (in part).
Nephtys (Aglaophamus) dibranchis. — Day, 1967 : 341, fig. 15.1 a-h.

Aglaophamus dibranchis Hartman, 1950 : 121.

REMARKS: No specimens available.

DISTRIBUTION: Australia; New Guinea, New Zealand, Indian Ocean.

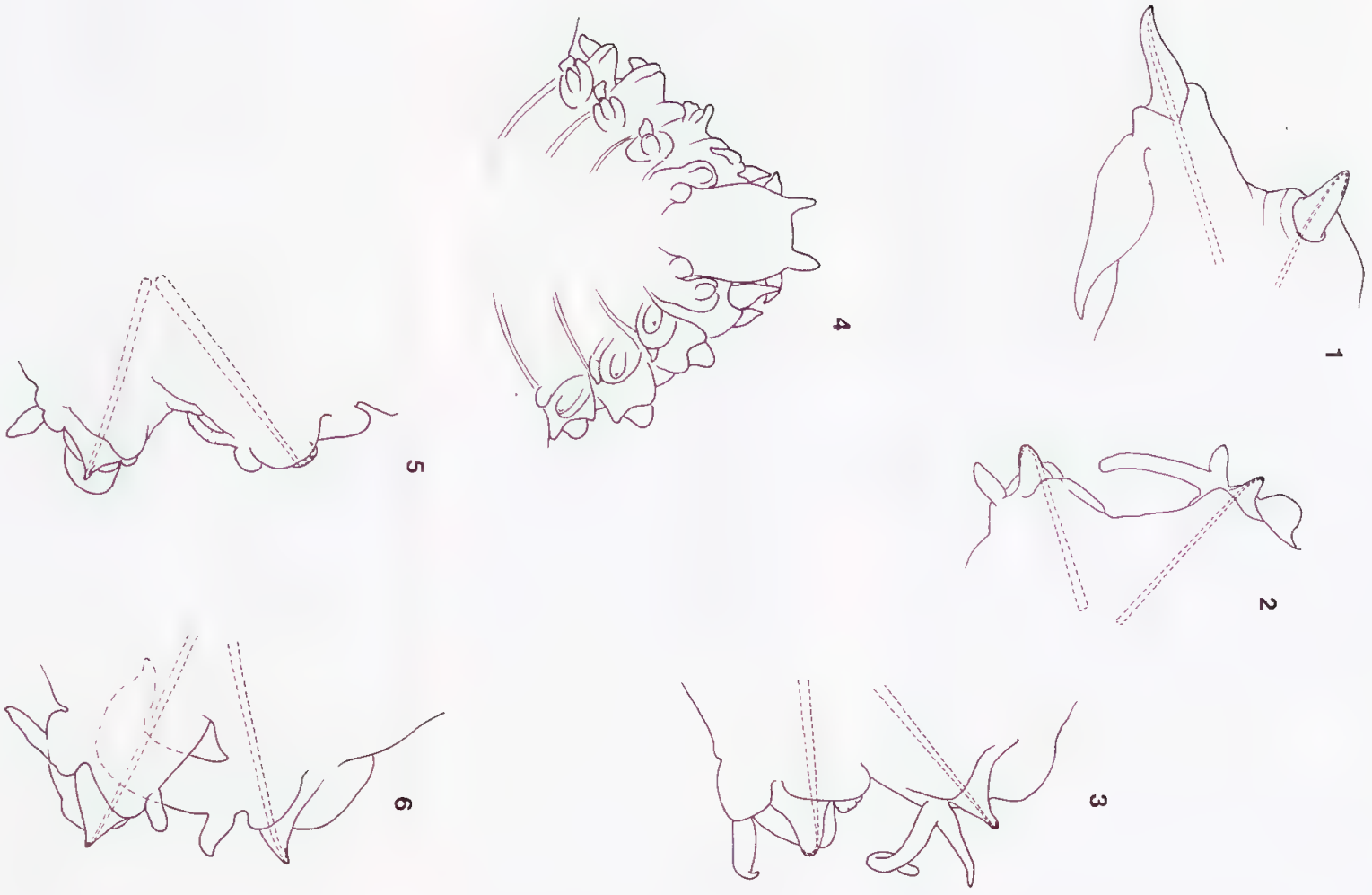
Aglaophamus gippslandicus n.sp. (Figs 1-3, 41; Table 1)

MATERIAL EXAMINED: Victoria: — 39°00'00''S 148°28'50''E (3.4), anterior fragment of 27 setigers (HOLOTYPE — AM W4911), 95 m, coll. C. Phipps, May 1969.

DESCRIPTION: Anterior fragment of 27 setigers, pharynx not everted (examined by dissection); length 7 mm, maximum width 1.4 mm, excluding setae. Segments short, 0.2 mm long near head, 0.3 mm long towards posterior end of fragment. Body colourless, no eyespots visible.

Prostomium 0.35 mm long, 0.3 mm wide, with anterolateral margin obliquely angled between subequal frontal antennae and ventrolateral palps; antennae short, on outer edge of frontal margin of prostomium, 0.1 mm apart, palps on lateral margin of prostomium, about 0.1 mm distant from 1st pair.

Pharynx with extrovert divided into short muscular distal region and longer inflated proximal region; distal region with 20 bifid distal papillae, proximal region with 14 longitudinal rows of subdistal papillae, 12-15 per row. No dorsal median subdistal papilla, proximal region without verrucae. Distal papillae 10 on each side of a dorsoventral slit; length of papillae up to 0.5 mm, with both portions similar in diameter but outer about 1½



Figs 1-6. *Aglaophamus gippslandicus* n.sp.: 1, first setiger (L, post. view, x 170); 2, ninth setiger (R, ant. view, x 68); 3, twentieth setiger (L, ant. view, x 68). Figs 4-6. —*Aglaophamus profundus* n.sp.: 4, anterior end (dorsal view, x 65); 5, seventh setiger (L, ant. view x 42); 6, twenty-seventh setiger (L, ant. view, x 42).

times length of inner. Subdistal papillae longest distally (up to 0.7 mm long), minute at proximal end of rows. Jaws paired, brown, unidentate, with triangular base embedded in pharyngeal muscles.

All parapodia biramous, projecting up to 0.7 mm (including setae) from body. First parapodium (fig. 1) reduced, directed anteriorly and lying adjacent to prostomium; notopodium with inconspicuous dorsal and ventral lamellae and a conical acicular lobe; neuropodium projecting beyond notopodium, with prominent conical acicular lobe and an elongate triangular ventral cirrus arising near distal end of neuropodium. Dorsal cirrus present by 2nd and subsequent setigers; small and pear-shaped on 2nd setiger; with distal elongation on 3rd setiger, becoming digitiform in later setigers, then elongate conical. Interramal cirrus present on 3rd parapodium, cirriform, gradually increasing in length in later setigers. By 10th setiger (fig. 2), parapodia with prominent conical acicular lobes, not obscured by pre- or postsetal lamellae; notopodial postsetal lamella obscured behind acicular lobe, well-developed above level of acicular lobe, broadly rounded, extending about as far as acicular lobe; notopodial presetal lamella low, obliquely rounded, best developed below level of acicular lobe; dorsal cirrus digitiform, nearly twice as long as wide (0.07 x 0.04 mm); neuropodial postsetal lamella obliquely rounded, about ½ length of acicular lobe and slightly wider, better developed above acicular lobe than below; neuropodial presetal lamella low, rounded, smaller than notopodial presetal lamella; ventral cirrus digitiform and a little longer than dorsal cirrus (0.09 x 0.04 mm); interramal region about 1/3 parapodial height, with interramal cirrus arising from base of dorsal cirrus and glandular cushion situated in ventral angle above neuropodial acicular lobe; interramal cirrus simple, not strongly curved inwardly, about as long as height of interramal region. By 20th setiger (fig. 3), parapodial lobes generally more strongly developed; notopodium with postacicular lamella broader, still obscured behind acicular lobe, dorsal cirrus nearly twice length of acicular lobe, and tapered; neuropodium with postacicular lamella extending almost as far as acicular lobe, preacicular lamella longer, and divided, with dorsal portion extending above level of acicular lobe to almost obscure the glandular cushion, ventral portion below level of setae, extending ventrally to base of ventral cirrus; latter as long as dorsal cirrus but not tapering as strongly.

Acicula stout, clear, colourless, extending to apex of acicular lobes but not projecting, with tips fine, strongly curved. A single aciculum in all parapodial rami.

Setae of three types: barred, spinulose and capillary. Barred setae restricted to preacicular positon, spinulose setae present only in postacicular position in anterior setigers and predominantly so in later setigers (Table 1). First setiger with barred setae and minutely-spinulose setae in notopodium, capillary setae in neuropodium.

DISCUSSION: The description of *Aglaophamus gippslandicus* n.sp. is based on an incomplete and poorly-preserved specimen, and the collection of further material will be needed for a fuller description. Three species have been described with 14 rows of subdistal papillae on the pharynx, cirriform dorsal cirri, distinct pre- and postsetal lamellae, and lacking lyrate setae: *A. erectans* Hartman, 1950, *A. malmgreni* (Théel, 1879) and *A. rubella* (Michaelsen, 1897). Both *A. erectans* and *A. malmgreni* have interramal cirri commencing on the ninth setiger rather than the third. *Aglaophamus rubella,* and particularly *A. rubella anops* Hartman, 1950, are very close to *A. gippslandicus* n.sp. *Aglaophamus rubella* has interramal cirri commencing on the third setiger, but has eyespots, 30-40 papillae in each row of pharyngeal subdistal papillae, a small erect cirrus on the dorsal side of the neuropodial postacicular lamella, and has a pigmented body. Fauchald (1963) further describes *A. rubella* as having pointed notopodial acicular lobes. *Aglaophamus rubella anops* lacks eyespots and has only 15-20 papillae in each row of pharyngeal subterminal papillae, but has interramal cirri commencing on the fourth

Table 1. *Aglaophamus gippslandicus* **n.sp. — setal formulae of setigers 1, 10 and 20. The number of each setal type are given as:**

preacicular notosetae	postacicular notosetae
preacicular neurosetae	postacicular neurosetae

Setiger	Setal Type			
	Barred	Spinose	Spinulose	Capillary
1 (left)	8 / — / —	— / — / —	— / 4 / —	— / — / —
10 (right)	10 / 16 / —	— / — / —	1 / 2 / > 30 / > 25	— / — / —
20 (left)	9 / 16 / —	— / — / —	2 / 2 / c.45 / c.40	— / — / —

setiger, acicula with exposed tips, notched notopodial pre- acicular lamellae, a slight prolongation or spur on the superior edge of the neuropodium, and has a reddish-brown body; no mention is made of the presence of spinulose setae in a preacicular position as occurs in *A. gippslandicus* n.sp.

Aglaophamus gippslandicus n.sp. can be distinguished from other species so far described from Australia by the combined features of having 14 rows of pharyngeal subdistal papillae and and no median dorsal subdistal papilla, pre- and postacicular lamellae not obscure, interramal cirri commencing on the third setiger, and cirriform dorsal and interramal cirri. This species in named after Gippsland in Victoria, the region where the holotype was found.

DISTRIBUTION: Australia (fig. 41).

ECOLOGY: The holotype was collected in 95 m from a sandy bottom.

Aglaophamus profundus n.sp. (Figs. 4-6, 41; Table 2)

Nephthys macrura (sic). – Benham, 1915 : 203-205, fig. 57. — Benham, 1916: 130. — Augener, 1927: 116.

Aglaophamus macroura. – Fauchald, 1963: 336. *(non* – Schmarda, 1861.)

Aglaophamus verrilli. – Paxton, 1974: 199, fig. 1.

MATERIAL EXAMINED: — Tasmania: — approx. 39°04'S 148°43'E (4.1), 1 spec. (HOLOTYPE — AM E5113), ant. fragment of 28 setigers, 2195 m, *F.I.S. Endeavour.*

DESCRIPTION: Anterior fragment (pharynx missing) of 27 setigers, 12 mm long; width 3 mm at 15th setiger (widest part of fragment); segments 0.4 mm long, segmentation not apparent across dorsum. Body light brown, prostomium mottled brown, no eyespots visible.

Prostomium (fig. 4) subovate, 0.75 mm long, 0.5 mm wide, narrower posteriorly, broadly rounded anteriorly; antennae and palps triangular, subequal, 0.2 mm long, 0.1 mm wide at base, antennae on anteroectal margin of prostomium, palps just behind and below antennae, directed ventrolaterally; a pair of nuchal organs near posteroectal margin of prostomium, everted.

Pharynx (after Benham, 1915) distally with 20 rather long bifid papillae and single dorsal and ventral median papillae surrounding buccal aperture; proximal region with shorter subdistal papillae decreasing in length towards base of pharynx, arranged in 20-22 longitudinal rows distally, reduced to 14 rows proximally. Jaws paired, brown, conical.

Parapodia biramous, moderately projecting. Parapodia of 1st setiger (fig. 4) displaced anteriorly and directed forward, lying adjacent to prostomium, parapodia of 2nd setiger directed anterolaterally. Parapodia of 1st setiger reduced, notopodium with low, rounded acicular lobe and obscure pre- and postacicular lamellae, neuropodium with prominent conical acicular lobe, obscure pre- and postacicular lamellae and with conical ventral cirrus about size of antennae and palps (0.18 mm long, 0.08 mm wide at base). Parapodium of 2nd setiger basically similar to remaining parapodia, with acicular lobes and pre- and postacicular lamellae in both rami, with dorsal and ventral cirrus but lacking interramal cirri. Interramal cirri first present by 7th setiger (fig. 5). At 7th setiger, notopodium with low rounded acicular lobe almost obscured by broadly-rounded preacicular lamella, postacicular lamella best developed above level of acicular lobe,

rounded, not extending beyond acicular lobe, dorsal cirrus small, rounded (0.07 mm long, 0.09 mm diameter); neuropodium with broad, conical acicular lobe with elongate apex and small rounded subacicular lobe, preacicular lamella wide, better developed above level of acicular lobe but not extending beyond it, postacicular lamella narrower than preacicular lamella, rounded, extending beyond acicular lobe, ventral cirrus digitate (0.14 mm long, 0.08 mm diameter), arising below subacicular lobe; interramal region ¼ parapodial height, with slender inwardly curved dorsal interramal cirrus (0.2 mm long, 0.04 mm diameter) and low rounded ventral interramal cirrus arising near dorsal margin of neuropodial postacicular lamella. At 27th setiger (fig. 6), parapodial lobes and lamellae better developed; notopodium with projecting conical acicular lobe, convex below, concave above, preacicular lamella low, rounded, best developed below level of acicular lobe, postacicular lamella broadly rounded, better developed above level of acicular lobe, dorsal cirrus longer than in 7th setiger, tapering (0.15 mm long, 0.09 mm diameter at base); neuropodium with conical, projecting acicular lobe, broader than in notopodium, with rounded subacicular lobe, preacicular lamella low, similar to 7th setiger, postacicular lamella rounded not extending as far as apex of acicular lobe, ventral cirrus digitate (0.35 mm long, 0.1 mm diameter); interramal region compressed, with stout tapering inwardly curved dorsal interramal cirrus (1.0 mm long, 0.3 mm diameter at base) and shorter flattened ventral interramal cirrus (0.2 mm long, 0.1 mm wide).

Acicula prominent, extending to but not projecting beyond apex of acicular lobes, usually with tip broadly curved, dorsad in notopodia, ventrad in neuropodia. A single aciculum in all parapodial rami. Acicula clear, colourless.

Setae of three types: barred, spinulose and capillary. Barred setae restricted to preacicular position, spinulose setae predominantly postacicular, absent in preacicular fascicles of anterior setigers. First setiger with barred and capillary setae in notopodium, capillary setae in neuropodium; barred setae present to last setiger of fragment, accompanied by several spinulose setae in later setigers (Table 2). Barred setae up to 0.2 —0.25 mm long, spinulose setae up to 0.5 —0.8 mm long, longest in posterior segments.

REMARKS: All records in the synonymy refer to the specimen originally described by Benham (1915). The description above differs from others in assigning the 7th setiger as the position of the first occurrence of the interramal cirri, rather than the 8th (Paxton, 1974) or 9th (Benham, 1915).

The holotype is in poor condition, and the shape of some parapodial lobes was difficult to determine: the notopodial postacicular lamellae, in particular, tended to be folded over on themselves, and they should probably be more prominent than indicated in figs 5, 6.

Although the holotype is incomplete, it can be distinguished from other species of *Aglaophamus* on the basis of the setae and parapodial structure. *Aglaophamus macroura* (Schmarda), to which the specimen was originally assigned, has long pointed postacicular lamellae (Hartman, 1967), among other differences. *Aglaophamus profundus* n.sp. is close to *A. verrilli* (McIntosh), but differs in lacking lyrate setae, lacking a dorsal cirrus on the 1st setiger, and in the proportions of the various parapodial lobes. The species name comes from the latin for deep, referring to the great depth at which the holotype was collected.

DISTRIBUTION: Australia (fig. 41).

ECOLOGY: Deep water (2195 m).

Table 2. *Aglaophamus profundus* **n.sp. — setal formulae of setigers 1, 7, 11 and 27, left side, expressed as in Table 1.**

Setiger	Setal Type: Barred	Spinulose	Capillary
1	11 | — / —	— | — / —	— | 12 / c.15
7	16 | — / 17 | —	1 | c.25 / — | c.30	— | — / — | —
11	15 | — / 17 | —	7 | c.30 / — | c.35	— | — / — | —
27	17 | — / 18 | —	1 | > 45 / 3 | > 45	— | — / — | —

Aglaophamus verrilli (McIntosh, 1885) (Figs 7-11, 41; Table 3)

Nephthys verrilli McIntosh, 1885: 163-164, pls 26 (figs 6, 7), 32A (fig. 8).

Nephthys dibranchis. — Hartman, 1938: 146 (in part). — Hartman, 1940: 237 (in part). — Rullier, 1965: 182-183. — Stephenson *et al.*, 1970:470.

Nephtys dibranchis. – Stephenson *et al.*, 1974: 113.

Aglaophamus dicirris Hartman, 1950: 122-124, pl. 18 (figs 1-8).

Aglaophamus verrilli. – Knox, 1960: 115. — Paxton, 1974: 199, fig. 1.

MATERIAL EXAMINED: LECTOTYPE, *A. verrilli* (BM 1885: 12:1:127). HOLOTYPE series, *A. dicirris*, 1 spec. (AHF Poly 0786).

Queensland: Townsville (1.1), 6 specs, coll. P. Arnold, comprising: 2 specs (AM W8456, 8457), 1 entire, 85 setigers, 1 ant. fragment of 49 setigers, from 19°18'S 147°11'E, 10.5 m, stns I19A, B, 18 June 1975; 1 spec. (AM W8458), ant. fragment of 64 setigers from 19°06'S 146°43'E, 11 m, stn U47A, 30 July 1975; 3 specs (AM W8459), 1 entire, 85 setigers, 2 ant. fragments of 43, 57 setigers, from 19°8'S 146°54'E, stn S36, 26 October 1974. — Moreton Bay (1.7), numerous specimens, coll. W. Stephenson and others, including 3 specimens (AM W8465, 8466), 2 entire, 84 and 85 setigers, 1 ant. fragment of 37 setigers, from stns 4C, D, 30 m, 2 km W of Shark Spit, April 1975; 1 specimen (QM G9549), entire, 85 setigers, from stn 1E2, 4 m, 1.6 km SE of South West Rocks, Peel Is., March 1970; 1 spec., from stn 1D5, locality as for stn 1E2, March 1970.

DESCRIPTION: (Based on a specimen here designated the lectotype.)

Anterior fragment of 53 setigers, with pharynx fully everted. Length 11 mm, maximum width 1.6 mm excluding setae, pharynx 1.5 mm wide, extending 2.4 mm beyond prostomium. In anterior segments, dorsal and ventral surfaces not obviously segmentally delineated. Anterior dorsum and ventrum with diffuse creamy-brown pigmentation, gradually lighter after 30th setiger; two faded eyespots present on posterior border of prostomium, widely separated. Epidermis smooth, somewhat iridescent dorsally.

Prostomium (fig. 7) approximately square, 0.4 mm wide and 0.35 mm long; anteriorly slightly excavate, posteriorly rounded; antennae and palps on anteroectal margins, short and digitate, palps 1½ times length of antennae. Body widest anteriorly, 2nd setiger 1.2 mm wide, with maximum body width 1.6 mm, between 15-25th setiger, thereafter tapering gradually posteriorly to 1.2 mm by 53rd setiger; segments compressed, much wider than long in anterior segments, varying from 0.1 mm long behind head to 0.3 mm long after 30-35th setiger.

Pharynx with extrovert divided into muscular distal region and inflated proximal region (fig. 7); distal region with 10 pairs bifid papillae and a pair of short, simple middorsal and midventral papillae surrounding a dorsoventral slit, papillae smaller in ventral and dorsal position on pharynx, each with cirriform outer portion and shorter radially-flattened inner portion; proximal region with 22 longitudinal rows of 6-8 subdistal papillae decreasing in size towards base of pharynx, covered with numerous verrucae. No median subdistal papilla. Verrucae irregularly arranged, more abundant in basal region of pharynx. Jaws not dissected but their bases visible externally in middorsal and midventral position between terminal and subterminal papillae.

Figs 7-11. *Aglaophamus verrilli* (BM 1885:12:1):7, anterior end, pharynx everted (dorsal view, x 38); 8, first setiger (L, dorsal view, x 160); 9, ninth setiger (L, ant. view, x 100); 10, twentieth setiger (L, ant. view, x 100); 11, fortieth setiger (L, ant. view x 100).

All parapodia biramous, projecting about ¼ body width or less. First parapodium reduced (fig. 8), directed anteriorly; notopodium with dorsal cirrus, a pair of inconspicuous dorsal and ventral lamellae surrounding a low, rounded acicular lobe; neuropodium with ventral cirrus but lacking obvious lamellae or projecting acicular lobe; dorsal and ventral cirri as long as posterior pair of prostomial antennae, enlarged basally. Second parapodium basically similar to remaining parapodia; noto- and neuropodia each with pre- and postacicular lamellae, acicular lobe and cirrus. Dorsal cirrus of 2nd setiger lamelliform, rounded, pre- and postacicular lamellae of both rami low, ventral cirrus similar to that of 1st setiger. Dorsal cirrus and notopodial postacicular lamella expanded to about full size by 4th setiger; neuropodial postacicular lamellae reach about full size by 6th setiger. Dorsal interramal cirrus from 7th setiger, short, rapidly developing to fill interramal region. Ventral interramal cirrus present from 8th setiger, digitate, often inwardly curved. Parapodium of 9th setiger (fig. 9) with prominent conical acicular lobes; notopodial postacicular lamella rounded, about twice length of acicular lobe and about 1½ times as long as high, arising above level of acicular lobe; notopodial preacicular lamella low, almost straight, not obscuring acicular lobe; dorsal cirrus digitiform, with expanded base, projecting as far as notopodial postacicular lamella; neuropodial postacicular lamella rounded, about 1½ times length of acicular lobe and about as long as wide, extending more below acicular lobe than above; neuropodial preacicular lamella present in anterodorsal position on neuropodium, low, narrow, not obscuring acicular lobe; a broadly rounded, low, subacicular lobe present at level of ventral cirrus, obscuring its base; ventral cirrus a little longer than dorsal cirrus, proximally expanded; interramal region about ¼ total parapodial height, completely filled by inwardly curved dorsal interramal cirrus and shorter digitate ventral interramal cirrus (obscured in fig. 9). Twentieth parapodium (fig. 10) similar except postacicular lamellae slightly larger and interramal region increased to about 1/3 parapodial height. By 40th setiger (fig. 11), acicular lobes enlarged and postacicular lamellae reduced so that notopodial postacicular lamella little larger than corresponding acicular lobe, and neuropodial postacicular lamella projecting somewhat less than acicular lobe.

Acicula usually prominent, extending to apex of acicular lobes, with tips variable in shape. A single aciculum present in both parapodial rami except perhaps in neuropodium of 1st setiger (not dissected). Acicula clear, yellowish in most setigers, tips of acicula generally curved, dorsad in notopodia, ventrad in neuropodia; in some setigers between 10-40th, tips straight, striated, bluntly acute.

Setae of four types: barred, spinulose, lyrate and capillary; barred setae restricted to preacicular position, lyrate setae to postacicular position, while spinulose setae predominantly postacicular (Table 3). Setae occur in two rows in each ramus, more or less continuous medially. First setiger with barred and capillary setae in notopodium, capillary setae in neuropodium; spinulose setae occur soon after 1st setiger, and lyrate setae are present by at least the 9th setiger. Barred and lyrate setae relatively short, about 0.15 mm long; spinulose setae much longer, especially those in the middle of each postacicular row, 0.23-0.65 mm long.

REMARKS: The relegation of *Aglaophamus dicirris* Hartman to synonymy with *A. verrilli* was made by Knox (1960), without comment, and was accepted by Paxton (1974), also without comment. In early work, Hartman (1938, 1940) grouped similar specimens with 14 and 22 rows of subdistal proboscidial papillae in *A. dibranchis* (Grube). Later, *Aglaophamus dicirris* was erected (Hartman, 1950) for specimens with 22 rows of subdistal papillae, and, at the same time *(ibid., p. 121) A. verrilli* and *A. dibranchis* were synonymised without comment. McIntosh (1885) described the different number of rows of subdistal papillae in the two species. The description of *A. dicirris* fits *A. verrilli* well;

Table 3. *Aglaophamus verrilli* **— setal formulae of setigers 1, 9, 20 and 40, left side, expressed as in Table 1.**

Setiger	Setal Type: Barred	Spinulose	Lyrate	Capillary
1	7 | — / —	— | — / —	— | — / —	6 | — / c.15
9	17 | — / 19 | —	— | 26 / — | > 30	— | 4 / — | 4	— | — / 1 | —
20	12 | — / 14 | —	1 | > 30 / 2 | > 30	— | 5 / — | 3	— | — / — | —
40	12 | — / 11 | —	— | 26 / — | > 20	— | 3 / — | 5	2 | — / 2 | —

our examination of a holotype specimen of *A. dicirris* confirms the synonymy established by Knox (1960).

DISTRIBUTION: Australia (fig. 41); New Zealand, India, North America to Panama.

ECOLOGY: In Australia, sheltered shallow subtropical waters, in sand to mud substrates to 30 m.

Inermonephtys Fauchald, 1968

Inermonephtys palpata Paxton, 1974 (Fig. 41)

Inermonephtys palpata Paxton, 1974: 200-202, figs 2-6.

MATERIAL EXAMINED: Queensland: Queens Beach, Port Denison, Bowen (1.2), approx. 20°03'S 148°15'E, 1 spec. (HOLOTYPE — AM W1710).

DESCRIPTION: Body pale, with pale orange pigmentation covering prostomium. Two orange stripes from nuchal organ to 2nd setiger. Pigmentation around bases of neuropodia of anterior 30 setigers. Prostomium subrectangular; frontal antennae absent; palps attached ventrally, large, each with a small projecting papilla. Nuchal organs present at posteroectal margins of prostomium.

Pharynx totally lacking papillae, with pair of spindle-shaped jaws. First segment directed forwards at either side of prostomium, continuous across mid-dorsum. Notopodia with digitiform acicular lobe, slender preacicular lamella and elongate postacicular lamella with rounded tips. Postacicular lamellae expanded in first 30 segments. Dorsal cirrus digitiform, extending beyond tips of notopodial lobes. Neuropodial acicular lobe with bulbous base and small inferior digitiform lobe. Pre- and postacicular neuropodial lamellae present, ventral cirrus well-developed. Interramal cirrus from second setiger, present on all subsequent setigers except last six. Interramal cirrus outwardly curved, with small basal lobe present after first 10 segments. Setae barred, spinose and lyrate. Two acicula per acicular lobe. Acicula project together, capped with single reddish plaque.

DISTRIBUTION: Australia (fig. 41).

ECOLOGY: Intertidal on sand flats, subtropical.

Micronephthys Friedrich, 1939

Micronephthys sphaerocirrata (Wesenberg-Lund, 1949) (Figs 12, 41)

Nephthys sphaerocirrata Wesenberg-Lund, 1949: 294-296, figs 24-26. — Day, 1953: 431.
Micronephthys sphaerocirrata Hartman, 1950: 130-131. (*non* Fauchald, 1968: 17-18, figs 36-40.)
Nephtys (Micronephthys) sphaerocirrata. — Day 1967: 347-349, figs 15.3 a-d.

MATERIAL EXAMINED: Queensland: — Townsille (1.1), 5 specs, coll. P. Arnold, comprising: 3 specs (AM W8963), stn E15C, 19°21'S 147°15'E, 4 m, 16 April, 1975; 2 specs (AM W8658), stn E15A, location, etc., as for stn E15C. — Middle Banks, near Tangalooma, Moreton Bay (1.7), 4 specs (AM W8463, 8464, QM G9547), coll. W. Stephenson and others, 1973.

Figs 12-16. *Micronephthys sphaerocirrata*: anterior end, pharynx everted (dorsal view, x 21). Figs 13-16. — *Nephtys australiensis* (AM W5786): 13, first setiger (R, dorsal view, x 67); 14, tenth setiger (L, ant. view, x 67); 15, twenty-second setiger (L, ant. view, x 67); 16, fiftieth setiger (L, ant. view x 67).

DESCRIPTION: Complete individual, 10 mm, with 62 setigers. Colourless, one pair of eyespots visible dorsally between 1st and 2nd setiger. Prostomium short and broad; antennae long and thin at frontal edge, palps longer, at base of prostomium. Pharynx with 10 pairs of bifid distal papillae and unpaired median dorsal papilla; proximal region of pharynx with 22 irregular rows subdistal papillae, 8-11 in each row, diminishing in size towards base of pharynx. No median dorsal subdistal papilla. No verrucae. First setiger directed forwards to lie parallel to prostomium. Distance between 1st and 2nd setiger greater than between subsequent setigers. Parapodia biramous with poorly-developed lamellae. Noto- and neuropodia with bluntly conical acicular lobes and small pre- and postacicular lamellae. First setiger with long ventral cirrus, following ventral and dorsal cirri small and globular. Interramal cirri completely absent. Parapodia with barred, capillary and deeply-bifurcate lyrate setae. Pygidium with long hair-like anal cirrus.

REMARKS: *Micronephthys sphaerocirrata* was described as having parapodial lamellae very sparsely developed (Wesenberg-Lund, 1949), and was figured with 8-11 papillae in each row of pharyngeal subdistal papillae. Day (1953) described material of *M. sphaerocirrata* from South Africa that lacked preacicular lobes and had 9 papillae in each subdistal row. Fauchald (1968) identified as *M. sphaerocirrata* material from Vietnam with prominent preacicular lamellae and with 14-16 papillae in each subdistal row. He noted the differences between the Vietnamese and South African material and suggested that they belonged to separate species, but was uncertain which, if either, should properly be identified as *M. sphaerocirrata*. The Australian material, with obsolete preacicular lamellae and 8-11 papillae in each subdistal row, is closest to Day's description. No significant difference is apparent between these and the original description; *M. sphaerocirrata* of Fauchald (1968) should probably be considered as a closely related but separate species.

DISTRIBUTION: Australia (fig. 41); Gulf of Iran, South West Africa, South Africa.

ECOLOGY: From sand or muddy sand; shallow subtidal to 500 m.

Nephtys Cuvier, 1817

(sensu Hartman, 1950)

Nephtys australiensis Fauchald, 1965 (Figs 13-16, 42)

Nephtys australiensis Fauchald, 1965: 334-335, figs 1-2. — Hutchings, 1974: 180. — Hutchings and Recher, 1974: 105, 108. — Paxton, 1974: 202-203, fig. 7 (in part). — Weate, 1975: 108.

Nephthys gravieri. — Augener, 1927: 116. — Rullier, 1965: 182 (*non* Augener, 1913).

MATERIAL EXAMINED: Queensland: — Hervey Bay (1.4) (AM W5362, 5365-5369), mangroves. — Fraser Is. (1.5) (AM W5363-5364). — Tin Can Bay (1.6) (AM W4980), mud flats. — Moreton Bay (1.7) (AM W5403, 6034, 8416, 8417), coll. W. Stephenson. — Moreton Bay (1.7) (QM G3635, 3637), det. Rullier. — Brisbane R. (1.8) (AM W7486, QM G9546).

New South Wales: — Wooli Ck (2.1) (AM W5268, 5269), intertidal. — Wallis L. (2.2) (AM W4220, 4223, 4229, 4230, 4233-4235, 4869-4874). — Myall L. (2.3) (AM W6125, 6127). — Fullerton Cove and Hunter R. (2.5-6) (AM W4733-4738), mud flats. — Careel Bay (2.9) (AM W5256, 5257, 5259, 5283, 5284, 5784-5793, 5846, 5847, 8232-8234), weed beds. — Port Jackson (2.10) (AM W5248, 5263, 5264). — Botany Bay (2.11) (AM W179, 184, 4498, 5264, 5271, 5272, 5694, 5695, 5736), coll. L. Collett. — Georges R. (2.12) (AM W7592,

7655-7665, 7672, 7673, 7682, 7689, 7697). — Bonnet Bay, Woronora R. (2.13) (AM W8189-8191), mud flats. — L. Conjola (2.17) (AM W5265). — Batemans Bay (2.18) (AM W5249, 8126).
— Clyde R. (2.19) (AM W8055-8099, 8115, 8116). — Wallaga L. (2.20) (AM W8100-8114). — Tuross L. (2.21) (AM W7792-8054, 8119-8125), weed beds and mud flats. — Broulee Bch (2.22) (AM W5266). — Merimbula (2.23).

Victoria: — Mallacoota (3.1) (AM W4832, 4833, 5267, 5516). — Bekta R. (3.2) (AM W8429-8431), weed beds. — L. Victoria (3.5) (AM W8651, 8652). — Western Port (3.7), WPES stns 1701-1741, abundant. — Port Phillip Bay (3.8) PPBES stns 131-139, in Hobsons Bay, common. — Hopkins R., Warrnambool (3.9) (AM W8469). — Fitzroy R. (3.11) (AM W8650). — Nelson (3.12) (AM W8468).

Tasmania: — Midway Pt, SE Tasmania (4.2) (TM K816, 817), coll. G. Prestedge. — Great Bay, Bruny Is. (4.3) (TM K813, 814), coll. I Mesibov.

South Australia: — Onkaparinga Est. (5.2) (AM W6063). — Port Vincent, Yorke Peninsula (5.3) (HOLOTYPE — AM W3873). — upper Spencer Gulf (5.4) (AM W5961), coll. S. Shepherd. — Chinamans Ck (5.5) (AM W5955-5959, 5961).

DESCRIPTION: Size range 7-85 mm, with 42-87 setigers. Anterior body oval in cross section, becoming rectangular towards posterior as distance between noto- and neuropodium increases, expanding interramal space. Body pale brown, typically with characteristic brown pigment (Paxton 1974). Intensity of pigmentation varies considerably in different populations, may be totally absent in juveniles. Prostomium pentagonal when pharynx fully withdrawn, rectangular when pharynx fully or partially everted. Pharynx divided into muscular distal region and inflated proximal region. Twenty-two longitudinal rows of subdistal papillae, each row of 6-9 papillae with slightly angular bases, decreasing in size towards base of pharynx. A single median dorsal subdistal papilla. Remainder of pharynx covered in numerous verrucae. Juveniles with full complement of papillae and verrucae.

First setiger (fig. 13) deflected forwards to lie adjacent to prostomium. Notopodium with triangular acicular lobe; small oval postacicular lamella and poorly developed notopodial cirrus; neuropodium with triangular acicular lobe with slightly expanded postacicular lamella. By 5th setiger, notopodium with entire triangular acicular lobe, expanded postacicular lamella and smaller foliaceous notopodial cirrus, preacicular lamella small and rounded, a small rounded supraacicular lobe on anterodorsal surface of acicular lobe; neuropodium with asymmetrical triangular acicular lobe, well-developed foliaceous postacicular lamella and digitiform neuropodial cirrus. Interramal cirrus present from 4th to about 50-60th setiger, absent thereafter. Inwardly curved interramal cirrus often completely fills the interramal space after first few anterior segments but only ½-⅓ fills the space in posterior segments. Base of interramal cirrus with small swelling. Surface of cirrus may be highly convoluted with a well ciliated epithelium. From 5th-22nd setiger (figs 14, 15), all parapodial lobes larger, except neuropodial cirrus; notopodial postacicular lamella 2 to 3 times as large as notopodial cirrus. Beyond 30th setiger (fig. 16), all parapodial lamellae less well developed.

Acicula with tips strongly curved, reflected towards dorsum and ventrum respectively, protruding slightly beyond tip of acicular lobe.

Setae of four types: capillary, barred, spinulose and spinose. Postacicular noto- and neurosetae of 1st setiger capillaries, preacicular notosetae barred. In holotype, barred preacicular notosetae continue to about 30th setiger, with approximately 10 in 5th setiger, 5-6 in 10th, 2-4 in 22nd and 1 at 30th. Rest of preacicular notosetae spinose or

spinulose with spinose dominant in posterior segments. Postacicular notosetae spinose and spinulose, with spinose setae dominating, plus a few capillaries. Barred setae present among preacicular neurosetae, approximately 11 in 5th setiger, 7-8 in 10th, 1-5 in 22nd, and 1-2 thereafter. Rest of neurosetae are spinose or spinulose, with spinulose dominant in preacicular and spinose in postacicular fascicles.

REMARKS: The description of *N. australiensis* by Fauchald (1965) omits any mention of the supra-acicular lobe which is clearly present in all setigers of the holotype apart from the first. This lobe could be mistaken for part of the divided acicular lobe characteristic of *N. gravieri*. Rullier (1965) presumably did confuse these lobes and referred his specimens to *N. gravieri*. Re-examination of this material confirmed Paxton's (1974) view that these specimens should be referred to *N. australiensis*. Fauchald (1965) does not mention the terminal papillae on the pharynx or presence of jaws, and he does not indicate the change in setal composition along the body.

Within the material examined there is some variation in the relative proportions of the parapodial lobes and interramal cirrus, which seems to be correlated with the size of the individuals and the substrate in which they are living. For example, individuals living in clean sand had smaller interramal cirri than those living in *Zostera* or *Posidonia* beds. There is also some variation in the segment on which barred setae terminate and in the intensity of pigmentation; specimens from Western Port in particular were heavily pigmented all over.

DISTRIBUTION: Australia (fig. 42).

ECOLOGY: Common in coastal lagoons, estuarine or sheltered bay conditions, often in *Zostera* or *Posidonia* beds. It is more common in muddy sand than clean sand, where it is replaced by *N. longipes*.

Nephtys gravieri Augener, 1913 (Figs 17-22, 42; Table 4)

Nephthys gravieri Augener, 1913: 123-125, pl.2 (fig. 5), text-figs 6a-c.

Nephtys mirocirris Fauchald, 1965: 335-336, figs 3, 4.

Nephtys gravieri. — Paxton, 1974: 203.

Nephtys australiensis. — Paxton, 1974: 202-203 (in part).

MATERIAL EXAMINED: SYNTYPE, *N. gravieri* (V-7896, Zoologisches Museum, Hamburg).

South Australia:— Clinton, Yorke Peninsula (5.3), 1 spec. (AM W3782) — HOLOTYPE of *N. mirocirris*). — upper Spencer Gulf, E side (5.4), 2 specs (AM W5960), ant. fragments of 42, 61 setigers, 9 m, coll. S. Shepherd, 11 September 1973.

Western Australia: — Bunbury Hbr (6.1), 3 specs (AM W8179), ant. fragments of 52, 54, 64 setigers, coll. A. Snell, March 1965. — Fishermans Jetty, Bunbury Hbr (6.1), 2 specs (AM W8180), ant. fragment of 66 setigers and 1 entire, 95 setigers, coll. A. Snell, 24 July 1965. — Leschenault Estuary plug, Bunbury (6.2), 1 spec. (AM W8178), ant. fragment of 70 setigers, coll. A. Snell, 20 June 1965. — Leschenault Est., Bunbury (6.2), 1 spec. (AM W4335), ant. fragment of 46 setigers, 0-1.2 m, coll. B. Collette, 8 February 1970. — Woodmans Pt, S of Fremantle (6.3), 2 specs (AM W8177), 15-30 cm, coll. L. Joll, 15 September 1975.

DESCRIPTION: (From AM W3782, holotype of *N. mirocirris*). Entire, pharynx not everted but dissected; length 49 mm for 87 setigers, maximum width 2.2 mm, excluding setae. Colour of body cream, browner towards posterior segments; surface pigmentation as a reddish-brown band on antennae and as small brown patches on posterodorsal surface of prostomium, and on postacicular lamella in anterior setigers.

Prostomium flattened, quadrate, 0.5 mm wide, slightly concave anteriorly, with short, tapering antennae and palps on dorsoectal margins (fig. 17). No eyespots visible. Body widest anteriorly, between 5-15th setigers, tapering gradually to last 5-10 setigers, when it tapers rapidly to the pygidium; a slender caudal cirrus, as long as last five setigers.

Proboscis with extrovert divided into short muscular terminal region with distal papillae and larger proximal region with subdistal papillae and verrucae; distal papillae bifid, subequal, in 10 pairs surrounding a dorsoventral slit; subdistal papillae in 22 longitudinal rows, each of 6-10 conical papillae directed proximally, up to 0.5 mm long, 0.1 mm wide, decreasing in size towards base of pharynx; verrucae numerous, randomly arranged. No median dorsal subdistal papilla. Jaws at position of 12th setiger, paired, brown, with conical tooth and widely-divergent support.

Parapodia biramous, projecting, about ⅕ body width in anterior setigers, increasing to ½ body width in posterior setigers. First parapodium (fig. 18) reduced, directed anteriorly, adjacent to prostomium; notopodium with a pair of inconspicuous dorsal and ventral lamellae enclosing a relatively prominent acicular lobe; neuropodium without lamellae or projecting acicular lobe, ventral cirrus digitiform, about ½ length of and situated immediately behind and below palps. Second parapodium generally similar to remaining parapodia; notopodium with pre- and postacicular lamellae, acicular and supra-acicular lobes and dorsal cirrus; neuropodium with pre- and postacicular lamellae, acicular and subacicular lobes and ventral cirrus. Interramal cirrus first present by 3rd setiger, small, with a low rounded papilla on dorsoectal margin, below dorsal cirrus. At 10th setiger (fig. 19), postacicular lamellae prominent, much larger than acicular lobes and preacicular lamellae; preacicular notopodial lamella low, supra-acicular lobe rounded, about same size as conical acicular lobe, dorsal cirrus angled ventrally; neuropodial preacicular lamella low, longer than notopodial, subacicular lobe similar, postacicular lamella large, auricular, ventral cirrus arising close to base of postacicular lamella, short; interramal region about ¼ parapodial height, ciliated; interramal cirrus short, barely curved outwardly, filling most of interramal space, with dorsoectal papilla unciliated. Twenty-first setiger (fig. 20) similar, except preacicular lamellae and supra- and subacicular lobes slightly larger, interramal space about ⅓ parapodial height, and interramal cirrus distinctly curved outwardly. By 40th setiger (fig. 21), parapodial lobes further separated; preacicular lamellae lower, exposing anterior face of acicular lobes, postacicular lamellae less prominent, supra- and subacicular lobes still apparent; interramal cirrus longer but extending only half-way to neuropodium. At 80th setiger (fig. 22), parapodia widely divergent, with interramal region about ⅗ parapodical height; acicular lobes project almost as far as postacicular lamellae, supra- and subacicular lobes low but still distinct, dorsal cirrus reduced to about size of dorsoectal papilla of interramal cirrus; interramal region not ciliated, interramal cirrus extending about ¼ distance to neuropodium.

Acicula usually prominent in acicular lobes, with expanded tips projecting beyond and overlying the acicular lobes. No aciculum visible in neuropodium of 1st setiger, occasionally two in remaining neuropodia but usually occurring singly in both noto- and neuropodia. Tips of acicula gently curved, dorsad in notopodia and ventrad in neuropodia. Acicula clear, yellow, except in anterior and middle segments, where acicular tips are opaque, red.

Table 4. *Nephtys gravieri* — setal formulae of setigers 1, 10, 21, 40 and 80, left side, expressed as in Table 1.

Setiger	Setal Type: Barred	Spinose	Spinulose	Capillary
1	11 · — / —	— — / —	— — / —	6 — / 12
10	— — / 1 —	— 12 / — 9	6 6 / 7 8	2 8 / 2 2
21	— — / — —	— 11 / — 11	7 13 / 9 10	— 1 / — 2
40	— — / — —	— 6 / — 9	4 6 / 5 7	1 8 / 1 2
80	— — / — —	— 13 / — 10	5 3 / 8 7	1 — / 1 1

Setae of four types: barred, spinose, spinulose and capillary (Table 4). Spines of spinulose and spinose setae arranged in rows, with the size of spines varying in both setal types. Spinose setae generally longer, stouter, with a basal region of 15-20 rows of larger apically-directed spines grading distally into spinules similar to those on spinulose setae; both types have fine, unornamented tips. Setae arranged in pre- and postacicular rows, with postacicular setae extending into subacicular and supra-acicular position in notopodia and neuropodia respectively. First setiger contains barred and capillary setae only. Minutely-spinulose setae occur from 2nd setiger and spinose setae from 4th setiger. From 8th setiger, barred setae reduced to one in each neuropodium, and are absent from 12th setiger and thereafter. Capillary setae become smaller after first 2-3 setigers, and may well be the tips of developing spinose and spinulose setae.

REMARKS: Fauchald (1965) described *N. mirocirris* as having barred setae, but did not give details of their distribution. Paxton (1974) stated that barred setae were absent, presumably from an examination of middle and posterior setigers only. Some variation in the position of the last barred setae is present in the material examined, extending as far as the 17th neuropodium in a small specimen and only as far as the 8th neuropodium in a large specimen. The acicula have strongly curved tips in some specimens, with apices red or almost colourless, and with or without apical caps.

An important characteristic of *N. gravieri* has been considered to be the incised notopodial acicular lobes. A supra-acicular lobe is present in most Australian species of *Nephtys;* in *N. australiensis* it can be almost as large as the preacicular lamella. A corresponding subacicular lobe is usually present in the neuropodium, although usually less well-developed than the supra-acicular lobe. The dorsal and ventral portions, respectively, of the incised noto- and neuropodial lobes of *N. gravieri* are in the same position as the supra- and subacicular lobes of other species, and it is here preferred to regard them as well-developed supra- and subacicular lobes; as such, they do not uniquely distinguish *N. gravieri* from other species of *Nephtys*.

DISTRIBUTION: Australia (fig. 42); India.

ECOLOGY: Shallow estuarine and coastal areas, in sand or muddy sand.

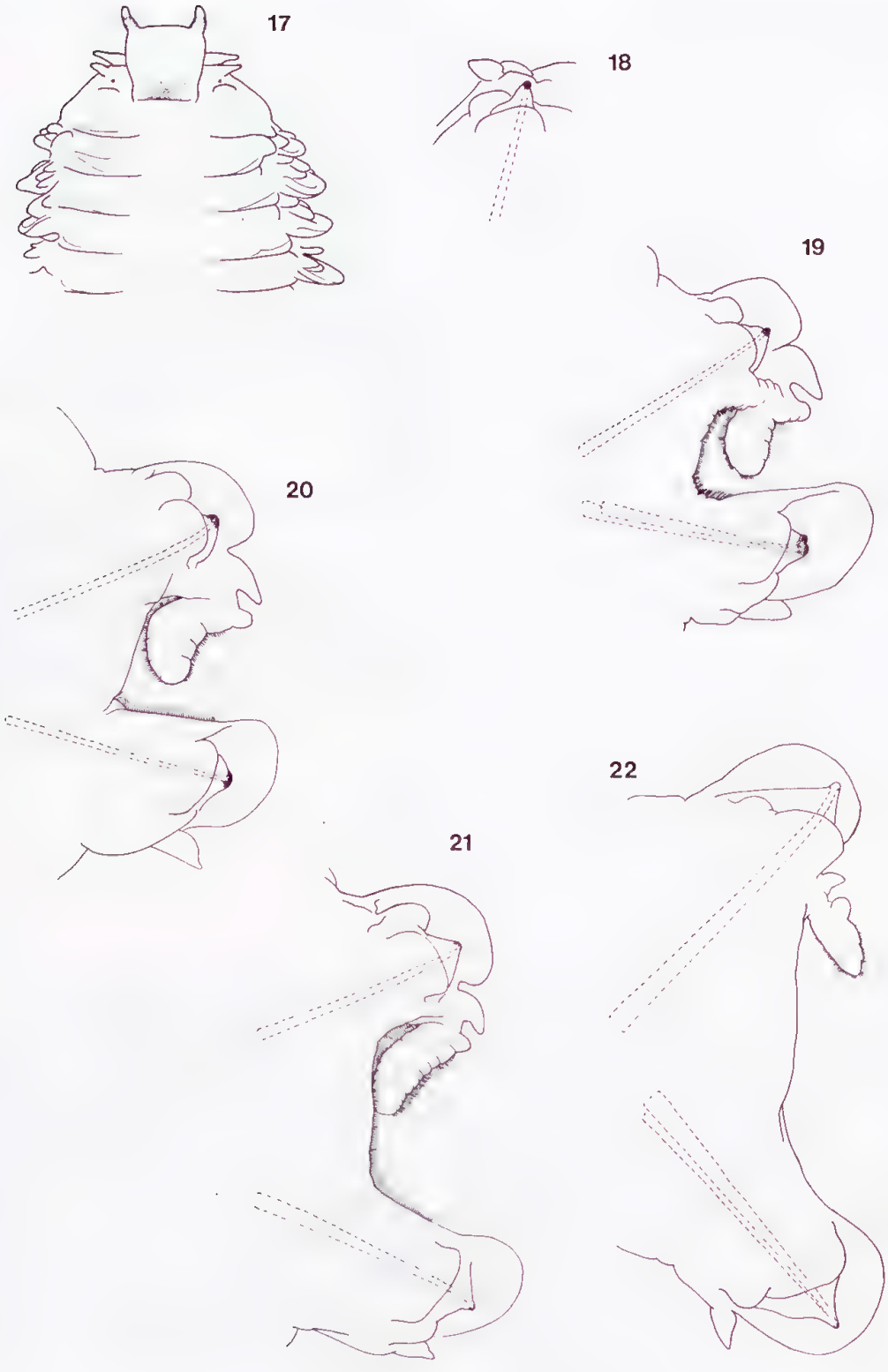
Nephtys inornata n.sp. (Figs 23-28, 43; Table 5)

Nephtys australiensis. — Fauchald, 1965: 334-335 (in part).

Nephtys sp. 1. — MMBW *et al.*, 1973: 370.

MATERIAL EXAMINED: New South Wales: — Woollahra Pt, Port Jackson (2.10), 1 spec. (AM W8182), 4-6 m. — 2 km E of Long Bay, 33°58'S 151°17'E (2.10a) (AM W8713), stn 4, 66 m, coll. Aust. Mus. Shelf Benthic Survey, July 1973. — Towra Bch, Botany Bay (2.11), 1 spec. (PARATYPE — USNM 53288), ant. fragment of 51 setigers, stn 220, coll. L. Collett, May 1975; 1 spec. (PARATYPE-BM ZB 1976:1), entire, 58 setigers, stn 242, coll. L. Collett, May 1975. — Gunnamatta Bay, Port Hacking (2.14), 1 spec. (AM W3580), entire, 74 setigers; 15 specs, coll. S. Rainer and A. Bothwell, including 1 spec. (HOLOTYPE-AM W8706), entire, 51 setigers, stn G2/9B, coll. 18 February 1975, 4.5 m; 3 specs (PARATYPES-AM W8708), ant. fragments of 25, 31; 39 setigers, stn G1/9B, coll. 8 January 1975; 1 spec. (PARATYPE-AM W8710), entire, 50 setigers, stn G1/10B, coll. 8 January 1975; 1 spec. (PARATYPE-AHF-Poly 1140), ant. fragment of 19 setigers, stn G2/1C, coll. 18 February 1975; 3 specs (PARATYPES-AM W8707), ant. fragment of 36 setigers and 2 entire, 46, 50 setigers, stn G2/3C, coll. 18 February 1975; 1 spec. (PARATYPE-AM W8709), entire, 50 setigers, stn G2/5C, coll. 18 February 1975. — Murrays Basin, Jervis Bay (2.16) (AM W8627), sand banks, stn 157, coll. NSW State Fisheries, 19 October 1972.

Victoria: — Western Port (3.7), 1 spec., WPES stn 1728, 10 m, coll. November 1973. — Port Phillip Bay (3.8), 668 specs from 64 stations, coll. 1969-1971, including PPBES stns 902/2, 932/2, 959/1, 916/1, 946/4, 982/4, 959/2, 970/1, 944/2, 913/1 (AM W8617-8627).



Figs 17-22. *Nephtys gravieri* (AM W3782): 17, anterior end (dorsal view, x 28); 18, first setiger (L, dorsal view, x 160); 19, tenth setiger (L, ant. view, x 67); 20, twenty-first setiger (L, ant. view, x 67); 21, fortieth setiger (L, ant. view, x 67); 22, eightieth setiger (L, ant. view, x 67).

Figs 23-28. *Nephtys inornata* n.sp.: 23, anterior end (dorsal view, x 33); 24, first setiger (R, dorsal view, x 80); 25, tenth setiger (L, ant. view, x 80); 26, twentieth setiger (L, ant. view, x 80); 27, fortieth setiger (L, ant. view, x 80); 28, prostomium and pharynx, everted (AHF Poly 1140, dorsal view, x 53).

DESCRIPTION: Holotype 13 mm long, 0.9 mm wide, for 51 setigers, entire; colourless except for eyespots, gravid. Prostomium flattened, rounded, about as long as wide; antennae and palps short, tapering, arising from anteroectal margin of prostomium, antennae about ½ length of prostomium, palps about ⅓ longer than antennae (fig. 23). A pair of small, brown eyespots visible near dorsal midline in posterior half of 2nd setiger. Pharynx of holotype not everted, not dissected. Body tapers gradually from 10th setiger to short, collar-like pygidium; anal cirrus slender, very short, about length of last 2 setigers.

Pharynx (described from paratypes AHF-Poly 1140 and AM W8707) divided into short muscular distal region with 18 bifid distal papillae and larger inflated proximal region with 20 subdistal rows of 4-7 conical papillae decreasing in size towards base of pharynx; no verrucae on proximal surface of pharynx, and no dorsal median subdistal papilla (fig. 28). Jaws paired, brown, horny, with heavy base and a pair of lateral extensions; a secondary tooth below the main tooth.

Parapodia of 1st setiger (fig. 24) reduced, directed forward to reach level of prostomium, with neuropodium just below and slightly anterior to notopodium; dorsal cirrus present as a short, digitate papilla about ½ length of antennae, arising from ventral surface of notopodium, ventral cirrus similar, about 1½ times size of notocirrus; neuropodium cylindroconical, with cirrus arising midway along ventral surface. Second setiger similar to remaining setigers, with entire pre- and postacicular lamellae and acicular lobes in both rami, dorsal and ventral cirri; preacicular and postacicular lamellae rounded, about size of conical acicular lobes; dorsal cirrus prominent, pearshaped, ventral cirrus as in 1st setiger. Postacicular lamellae larger in posterior parapodia, fully-developed by 5th setiger; interramal cirrus present from 5th setiger as a short, stout lobe with ciliated, convoluted surface, weakly outwardly curved. At 10th setiger (fig. 25), preacicular lamellae extend as far as acicular lobes, smaller than postacicular lamellae; dorsal cirrus a small conical papilla arising from dorsal border of interramal cirrus, reduced compared with anterior setigers; ventral cirrus arising at ventral junction of pre- and postacicular lamellae; interramal cirrus short, stout, ciliated, occupying most of interramal region; neuropodium ciliated on dorsal surface. Parapodium of 20th setiger (fig. 26) similar except that interramal region larger, with a number of strongly ciliated areas, and postacicular lamellae somewhat reduced although still larger than acicular lobes and preacicular lamellae. Near tail, parapodial rami become widely divergent, so that each setiger approximately quadrate in section. By 40th setiger (fig. 27), postacicular lamellae reduced to size of acicular lobes or slightly smaller, preacicular lamellae also somewhat reduced; interramal cirrus smaller than in anterior setigers, some ciliated patches still evident in interramal region.

A single aciculum present in all noto- and neuropodia, reaching surface of or barely projecting from acicular lobe, bluntly pointed in anterior and middle setigers and with curved tips in setigers near tail. Aciculum of 1st neuropodium reduced, not reaching surface. All acicula with fine lateral striations near apex.

Setae of three types: barred, spinulose and capillary. Setae generally arranged in pre- and postacicular rows, with barred setae preacicular only (Table 5). Notopodium of 1st setiger with barred preacicular setae and capillary postacicular setae, neuropodium with capillaries emerging in a single group from apex of neuropodium. In later setigers, barred setae replaced gradually by spinulose setae, dorsally between setigers 9-15, ventrally by setigers 10-15; barred setae absent by setiger 16.

REMARKS: Paratypes exhibit some variation from the holotype. The size of most of the specimens examined is 10-15 mm in length and 0.6-0.9 mm in width, for 46-51 setigers. The position of the eyes varies from the 1st setiger to the 4th. The position of the

Table 5. *Nephtys inornata* **n.sp. — setal formulae of setigers 1, 2, 10, 20 and 40, expressed as in Table 1.**

Setiger	Setal Type: Barred	Spinulose	Capillary
1 (L,R)	5-6 | — / —	— | — / —	— | 2-4 / 6-7
2 (L,R)	11-13 | — / 9-11 | —	— | — / — | —	2 | 3-5 / 1-2 | 7
10 (L)	7 | — / 6 | —	4 | 17 / 3 | 15	— | — / — | —
20 (L)	— | — / — | —	10 | 19 / 5 | 25	— | — / — | —
40 (L)	— | — / — | —	7 | 15 / 9 | 11	— | — / — | —

last barred setae is relatively constant, usually setiger 14-15 (8 specimens) but sometimes later.

The species is distinguished from most other species by the absence of spinose setae, the possession of barred setae in anterior setigers only, and the number of apical and subapical papillae on the pharynx (18 and 20 rather than 22 or 14 in most species). Four species have been described previously with a number of features similar to *Nephtys inornata* n.sp.: proximal region of the pharynx without verrucae, no unusually-modified setae, postacicular lamellae entire and not greatly prolonged, no erect lobe on the superior border of the neuropodium, and interramal cirri not foliaceous. These are *N. cornuta* Berkeley from the northwestern Pacific, *N. hystricis* McIntosh from the eastern Atlantic and Mediterranean, *N. panamensis* Monro from the central west Pacific, and *N. phyllocirra* Ehlers from the West Atlantic. None of these has eyespots. Three of the species have 22 rows of subdistal papillae on the pharynx (not known for *N. cornuta). Nephtys cornuta* has bifurcated ventral prostomial antennae, smooth postacicular setae and lacks preacicular setae in posterior setigers (Hartman, 1950). *Nephtys hystricis* has a pharynx with 22 rows of 35 small papillae and with a median dorsal papilla; interramal cirri commence on setiger 9, and are large and curved outwardly (Fauvel, 1923). *Nephtys panamensis* has outwardly curved interramal cirri present from the 3rd setiger, has well-developed parapodial lobes, and the postacicular setae include serrated (= spinose) setae (Hartman, 1940). *Nephtys phyllocirra* has barred setae in posterior setigers, although in reduced numbers, and the interramal cirri commence on the 6th setiger (Hartman, 1950).

Nephtys inornata n.sp. is distinguished from the closely-related *N. mesobranchia* n.sp. by the earlier commencement of interramal cirri, differences in parapodial shape, and the absence of a median dorsal subdistal papilla on the pharynx. The name *inornata* is derived from the absence of verrucae on the pharynx.

DISTRIBUTION: Australia (fig. 43).

ECOLOGY: Shallow, sheltered coastal areas, intertidal to 25 m, in sand, muddy sand, or firm mud.

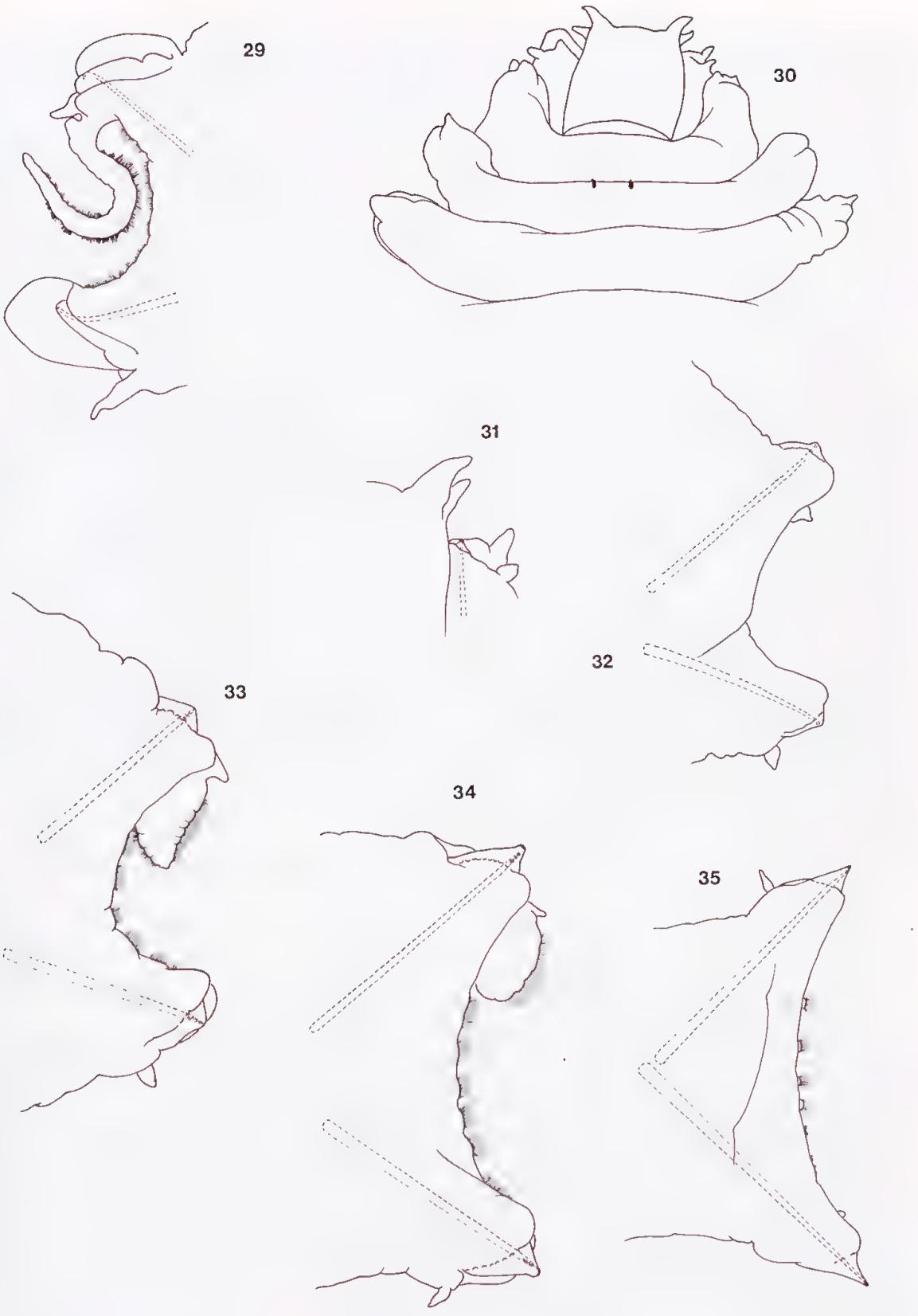
Nephtys longipes Stimpson, 1856 (Figs 29, 43)

Nephtys longipes Stimpson, 1856, 392.
Nephtys vikingensis Paxton, 1974: 204-207, figs 8-13.
Nephtys picta. — Knox and Cameron, 1971: 28, figs 15-16 (*non* Ehlers, 1868).
Nephtys sp. — Hutchings, 1974: 181.

MATERIAL EXAMINED: The holotype and paratypes of *N. vikingensis* are here designated the neotype and paraneotypes, respectively, of *N. longipes*. Queensland: — Moreton Bay (1.7) (AM W5401), coll. J. D. Ogilby. — Middle Banks off Tangalooma, Moreton Bay (1.7) (AM W8420, QM G9548), coll. W. Stephenson and others.

New South Wales: — Wallis L. (2.2) (PARANEOTYPE-AM W5252, AM W5392-5395, 5397-5400). — Burwood Bch, Newcastle (2.7) (AM W7391, 7394-7396), 16-20 m. — Belmont Bch, Newcastle (2.8) (AM W7388-7390, 7392, 7393, 7396), 12-22 m. — Seven Mile Beach, Gerroa (2.15) (AM W5255). — Batemans Bay (2.18) (NEOTYPE-AM W5251, PARANEOTYPES-AM W5253-5254, AM W5392-5395, 5397-5400).

Victoria: — Mallacoota Inlet and Bekta R. (3.1, 3.2) (AM W8434-8438). — Wilsons Promontory (3.6). — Port Phillip Bay (3.8) (NMV G1789).



Figs 29-35. *Nephtys longipes* (AM W5251): twenty-seventh setiger (L, ant. view x 53). Figs 30-35. — *Nephtys mesobranchia* n.sp.: ant. end (dorsal view, x 32); 31, first setiger (L, ant. view, x 85); 32, fifth setiger (L, ant. view, x 53); 33, tenth setiger (L, ant. view, x 53); 34, twentieth setiger (L, ant. view, x 53); 35, fortieth setiger (L, ant. view x 53).

DESCRIPTION: Preserved body pale often with slightly bluish iridescence, long flowing golden setae. Size range 55-100 mm. Pigmentation absent. Prostomium oval, with triangular translucent preantennal lobe. Antennae arise at base of preantennal lobe, palps arise further down the prostomium. Pharynx with 10 pairs bifid distal papillae separated by single middorsal and midventral papillae. Twenty-two rows of subdistal papillae, each row of 5-7 papillae. Proximal surface covered with verrucae. Outwardly curved interramal cirrus present from 3rd setiger almost to pygidium. Notopodia with rounded, equal acicular lobe and postacicular lamella, preacicular lamella short and rounded, supra-acicular lobe rounded, slightly elongated, dorsal cirrus digitate. Neuropodia with rounded acicular lobe, pre- and postacicular lamellae, preacicular smallest and postacicular largest. Ventral cirrus subconical, with distal notch (fig. 29). Setae long and flowing, barred, spinose and spinulose.

REMARKS: Stimpson (1856) described *N. longipes* from the sandy intertidal areas of Botany Bay, and the type was probably destroyed in the Chicago Fire (Pettibone, pers. comm.). Although the description is very brief, Stimpson does indicate that it is a very large species (3 inches), bluish white in colour, with very long setae, and with antennae 'placed rather near the base of the head'. The only species of *Nephtys* recorded from Australia which coincides with this is *N. vikingensis* Paxton, 1974. Paxton agrees with Augener (1922) that *N. longipes* is indeterminable, but sufficient information is given in Stimpson's description for *N. vikingensis* to be synonymised with *N. longipes*. The other species of *Nephtys* occurring intertidally around Sydney are *N. australiensis* and *N. inornata*. These are smaller species than *N. longipes* and have shorter setae. *N. australiensis* has a very characteristic pigmentation pattern, and the prostomium does not project beyond the antennae in either species.

The description given by Paxton (1974) for *N. vikingensis* has been emended to note the presence of a supra-acicular notopodial lobe, and the distal notch in the ventral cirrus. The holotype of *N. vikingensis* was selected as the neotype of *N. longipes* and several paratypes were selected for a paraneotype series.

DISTRIBUTION: Australia (fig. 43).

ECOLOGY: Intertidal to shallow subtidal, in clean sand in sheltered coastal areas.

Nephtys mesobranchia n.sp. (Figs 30-35, 43; Table 6)

MATERIAL EXAMINED: Queensland: — Calliope R., Gladstone (1.3), 7 specimens, coll. P. Saenger, 26-28 November 1975, comprising: 1 spec. (HOLOTYPE-AM W8653), entire gravid female, 49 setigers, stn 1/8/3, 8.5 km from mouth, 5 m; 1 spec. (PARATYPE-AM W8654), ant. fragment of 32 setigers, stn 1/4/2, 2 km from mouth, 5 m; 1 spec. (PARATYPE-AM W8657), ant. fragment of 39 setigers, stn 1/8/5, 8.5 km from mouth, 3 m; 4 specs, 1 ant. fragment of 28 setigers (PARATYPE-AM W8656), three entire, of 48 setigers (PARATYPE-BM ZB 1976:2), 43 setigers (PARATYPE-USNM 53289), 49 setigers (PARATYPE-AHF-Poly 1139), stn 1/7/75, 10 km from mouth, 3 m.

DESCRIPTION: Holotype entire, 49 setigers, proboscis not everted (examined by dissection); length 23 mm, maximum width 2.2 mm, excluding setae. Body without pigmentation, setae straw-coloured; 1 pair black eyespots visible dorsally at anterior border of 3rd setiger, about 0.15 mm apart (fig. 30).

Prostomium approximately square, 0.35 mm long and 0.4 mm wide, slightly convex anteriorly, with one pair antennae and one pair palps, subequal, short, tapering, on

anteroectal margins, about 0.1 mm long. Body widest at about 10-15th setiger, narrowing slowly to about 40th setiger and tapering rapidly thereafter. Anal cirrus short, slender, about length of last 3 setigers (PARATYPE AHF-Poly 1139). First setiger reduced dorsally, almost obscure by 2nd setiger; width of 2nd setiger 1.0 mm, 10th setiger 1.8 mm, 20th setiger 1.6 mm, 40th setiger 1.5 mm, with setae extending 0.15-0.2 mm on each side; segments compressed, wider than long, especially near prostomium, length of 2nd setiger 0.15 mm, 10th setiger 0.4 mm, 20th setiger 0.6 mm, 40th setiger 0.6 mm; intersegmental region of 1st-12th setiger not markedly constricted, obviously so thereafter; intersegmental region around 40th setiger 0.6 mm wide.

Pharynx with extrovert divided into usual muscular distal region and inflated proximal region; distal region with 20 bifid papillae surrounding a dorsoventral slit, 10 on each side, each papilla with cirriform outer portion and shorter radially-flattened inner portion, papillae smaller towards middorsal and midventral position; proximal region with prominent median dorsal subdistal papilla and with 18 longitudinal rows of 10-12 subdistal papillae extending half way to base of pharynx, papillae largest distally, almost microscopic proximally. Median subdistal papilla slender, 0.4 mm long, 2-3 times length of other subdistal papillae. Verrucae absent. Jaws paired, brown with broadly-conical apex and with triangular base embedded in pharyngeal muscle. In midventral position, distal to jaws and close to terminal papillae, a radially-arranged line of 4 or so pairs narrow brown cuticular ridges.

Parapodia biramous, not strongly projecting. Parapodia of 1st and 2nd setiger directed anteriorly, with 1st parapodium lying adjacent to prostomium just behind and below antennae, 2nd parapodium lying above and behind 1st; parapodia of 3rd setiger directed anterolaterally (fig. 30). Parapodium of 1st setiger (fig. 31) reduced, notopodium with low broadly-conical acicular lobe and digitate dorsal cirrus (0.04 mm long, 0.03 mm wide), neuropodium projecting slightly, with no distinct lobes, ventral cirrus digitate (0.06 mm long, 0.04 mm wide). Second parapodium basically similar to remaining parapodia, with acicular lobes and pre- and postacicular lamellae in both rami and with dorsal and ventral cirri. At 5th setiger (fig. 32), acicular lobe of notopodium low, mammilliform, not obscured by pre- or postacicular lamellae, preacicular lamella present as rounded lobe below level of acicular lobe, obscure above, postacicular lamella a short rounded lobe not visible from anterior view; dorsal cirrus short, bulbous (0.06 mm long, 0.06 mm diameter) with low conical tip; neuropodium with conical broadly-depressed acicular lobe, preacicular lamella developed only as a rounded lamella above level of acicular lobe, obscure below, postacicular lamella better developed than in notopodium, broadly rounded, best developed above level of acicular lobe but not visible from anterior view, ventral cirrus short, digitiform (0.08 mm long, 0.04 mm wide); interramal region about half height of parapodium, with some ciliation on dorsal surface of neuropodium. Interramal cirrus first present on 7th setiger, rapidly reaching full size. Parapodium of 10th setiger (fig. 33) with lobes and lamellae better developed than 5th parapodium; notopodium with low conical acicular lobe, preacicular lamella only developed above and below level of acicular lobe, postacicular lamella obscured, dorsal cirrus a short tapering lobe 0.05 mm long on dorsoectal margin of interramal cirrus, projecting beyond and below preacicular lamella; neuropodium with mammilliform acicular lobe, preacicular lamella developed above level of acicular lobe, obliquely rounded, reaching just beyond acicular lobe, postacicular lamella rounded, extending beyond and above acicular lobe, ventral cirrus short, digitate (0.08 mm long, 0.04 mm wide); interramal region 1/3 parapodial height, irregularly ciliated, with interramal cirrus extending about ½ height of interramal space; interramal cirrus short, barely curved outwardly, strongly ciliated. By 20th setiger (fig. 34), parapodial rami widely divergent, acicular lobes projecting beyond pre- and postacicular lamellae, dorsal cirrus expanded proximally and narrowly-tapering distally, ventral cirrus narrower, tapering (0.08 mm

Table 6. *Nephtys mesobranchia* **n.sp. — setal formulae of setigers 1, 5, 10, 20 and 40, left side, expressed as in Table 1.**

Setiger	Setal Type		
	Barred	Spinulose	Capillary
1	8 | — / —	— | — / —	— | 1 / c.6
5	12 | — / 12 | —	— | 13 / — | 16	— | 2 / — | 1
10	11 | — / 12 | —	2 | 22 / 3 | 26	— | — / 1 | 3
20	— | — / 2 | —	16 | 32 / 13 | 32	— | — / — | —
40	— | — / — | —	5 | 9 / 5 | 17	— | — / — | —

long, 0.03 mm wide), interramal region 2/3 parapodial height with ciliation restricted to raised pads and with interramal cirrus ciliated, stout, occupying 1/3 of interramal space. Interramal cirrus absent from 24th setiger and thereafter, disappearing abruptly. By 40th setiger (fig. 35), pre- and postacicular lamellae reduced, acicular lobes conical, strongly projecting, dorsal cirrus much reduced, interramal region about 4/5 parapodial height, with scattered raised ciliated pads.

Acicula usually prominent, extending to apex of acicular lobes, occasionally with minute slender curved tip projecting beyond acicular lobe, recurved dorsad in notopodia, ventrad in neuropodia. A single aciculum in all parapodial rami except perhaps neuropodium of 1st setiger, where not seen (not dissected). Acicula clear, colourless, generally with fine lateral striations near tips.

Setae of three types: barred, spinulose and capillary. Barred setae restricted to preacicular position, while spinulose setae predominantly postacicular in anterior setigers (Table 6). First setiger with barred and capillary setae in notopodium, capillary setae in neuropodium; spinulose setae appear in 2nd setiger and then predominate among postacicular setae; barred setae gradually replaced by spinulose setae, with barred setae present to 21st setiger, absent thereafter. Barred setae longest in anterior setigers, up to 0.35 mm, reducing to 0.15-0.2 mm by 20th setiger; spinulose setae shorter anteriorly, 0.35-0.4 mm, increasing to maximum of 0.65 mm on 20th setiger.

REMARKS: The four entire specimens examined ranged from 43-49 setigers, with the smaller specimens having several achaetous segments before the pygidium; one 49-setiger specimen was ovigerous. Eyespots were visible in the 2nd or 3rd setiger in all specimens. In all entire specimens the interramal cirri were restricted to the anterior half of the body; the range of setigers bearing interramal cirri was 7-21 (1 spec.), 7-22 (3 specs), 7-23 (1 spec.), 8-22 (1 spec.).

In general appearance, *N. mesobranchia* n.sp. is close to *N. oligobranchia* Southern and *N. polybranchia* Rullier, euryhaline species recorded from Indo-Pacific areas, including India, Gulf of Siam, China and Vietnam (Fauchald, 1968). *Nephtys mesobranchia* n.sp. differs from these in having 18 rows of subdistal papillae on the pharynx, rather than 22, and in possessing eyes; it differs further from *N. oligobranchia* in lacking lyrate setae and from *N. polybranchia* in the later commencement of interramal cirri (7-8th setiger, rather than 4th), the presence of a median subdistal papilla on the pharynx and the absence of verrucae. In possessing eyespots, only 18 rows of subdistal papillae and lacking verrucae, *N. mesobranchia* n.sp. is close to *N. inornata* n.sp., but the two can be easily differentiated by the different position of the interramal cirri and the presence of a single dorsal subdistal papilla in *N. mesobranchia* n.sp. The specific name *mesobranchia* indicates the intermediate position of the species between *N. oligobranchia* and *N. polybranchia*.

DISTRIBUTION: Australia (fig. 43).

ECOLOGY: *Nephtys mesobranchia* n.sp. was collected from a wide variety of sediment types, from mud and sandy mud to coarse river gravel with coarse sand, and the species appears to tolerate some degree of salinity reduction, with recorded salinities averaging 24.5-30.4‰.

Nephtys paradoxa Malm, 1874 (Fig. 43)

Nephtys paradoxa. – Fauchald, 1963: 13-15, figs 1A, 2B, 3C. — Paxton, 1974: 204.

MATERIAL EXAMINED: New South Wales: — 53 km from Green Cape, approx. 37°16'S 15°10'E (2.24), 1 spec. (AM W5247), 860 m, coll. F.I.S. *Endeavour*, 2 October 1912.

DESCRIPTION: Incomplete specimen, 35 mm long and 7 mm wide for 37 segments, body uniform pale brown. Prostomium pentagonal, anterior margin slightly concave. Antennae long and pointed, palps similar length to antennae but thicker. Pharynx with 18 pairs bifid distal papillae. Twenty-two rows papillae present. Proximal surface of pharynx without verrucae. Interramal cirrus present from 9th setiger as small outgrowth ventral to dorsal cirrus; fully developed by 25th-27th setiger, bearing two lateral foliaceous lamellae, subsequently interramal cirrus becomes smaller. Notopodia with obliquely-rounded acicular lobe, rudimentary preacicular lamella and small postacicular lamella, triangular dorsal cirrus. Neuropodia with rudimentary preacicular lamella, postacicular lamella longer than acicular lobe, ventral cirrus triangular with constricted base. Setae relatively short and stout, comprise spinose and barred setae.

DISTRIBUTION: Australia (fig. 43); northern Atlantic, Sea of Japan, Sea of Okhotsk, subantarctic areas off Chile.

ECOLOGY: Deep-water species, 50-860 m.

Nephtys semiverrucosa n.sp. (Figs 36-40, 43; Table 7)

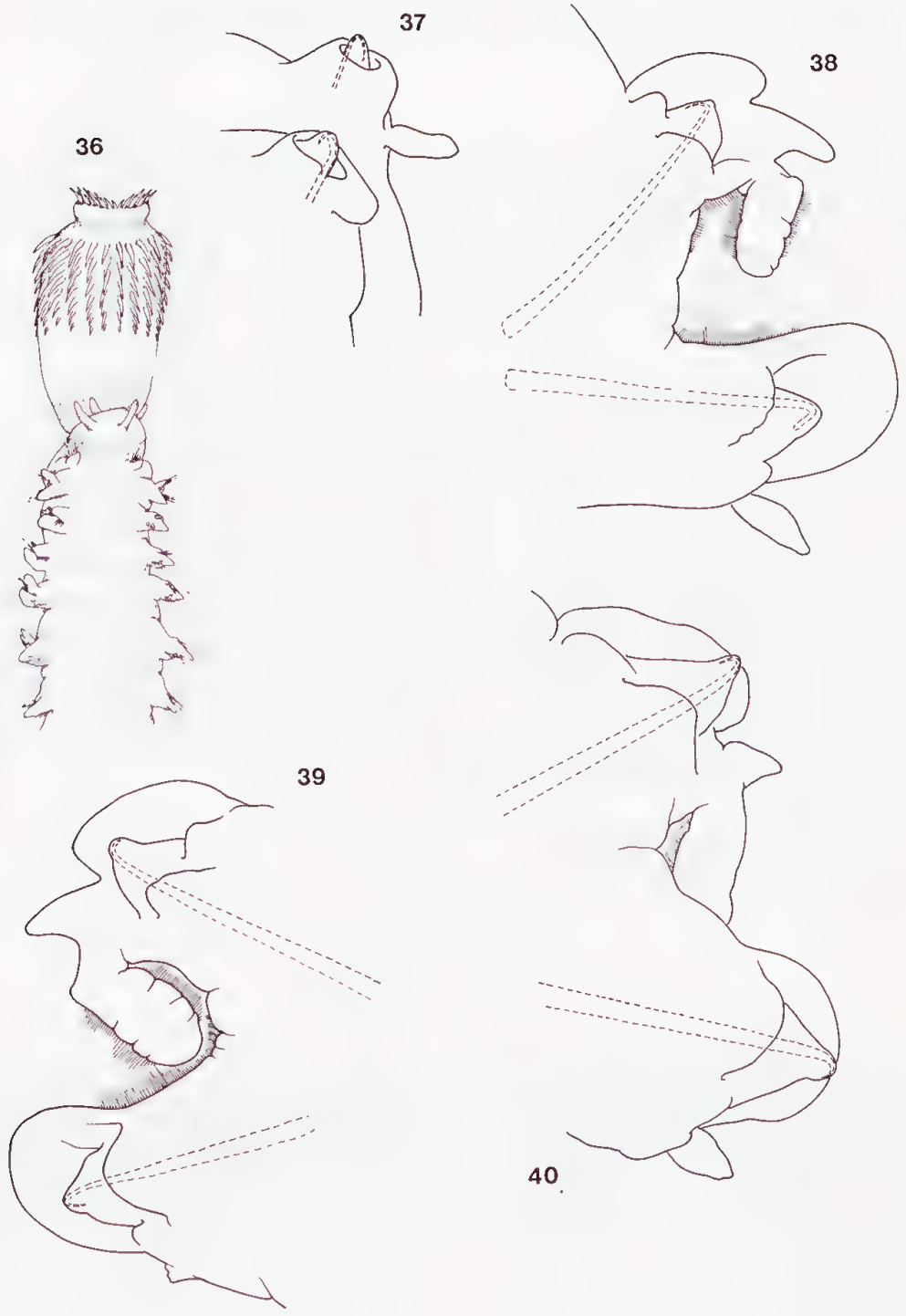
MATERIAL EXAMINED: Northern Territory: — Fannie Bay, Darwin (7.1), 1 spec. (HOLOTYPE-AM W5865), entire, 63 setigers, coll. E. Pope and R. Williams, 23 October 1965.

DESCRIPTION: Complete individual, pharynx everted; length 18 mm for 63 setigers (excluding proboscis), maximum width at 5-15th setiger 0.8 mm, excluding setae; segments 0.8 mm wide and 0.2 mm long at 15th setiger, 0.7 mm wide and 0.35 mm long at 40th setiger. Caudal cirrus present, length of last 7 setigers. Gametes absent.

Prostomium pentagonal, slightly extended anteriorly (fig. 36), with one pair antennae and one pair palps, antennae at base of anterior extension of prostomium, palps at base of prostomium. Eyespots not apparent.

Pharynx divided into muscular terminal region with 10 pairs bifid distal papillae having outer portion 1½ times length of inner, situated around elongated dorsoventral aperture of pharynx, and inflated basal region with 22 longitudinal rows of subdistal papillae, 4-7 papillae in each row, becoming smaller towards base of pharynx; no median dorsal subdistal papilla; basal region of pharynx with a proximal ring of patches of verrucae, distal portion of basal region without verrucae.

First setiger (fig. 37) displaced forwards but not adjacent to prostomium, with small acicular lobe and postacicular lamella. Acicula with red square tips curved away from interramal space. Interramal cirri from 4th setiger almost to pygidium, short, not markedly curved outwardly, occupying about ½ interramal space in anterior setigers, smaller in posterior setigers. Parapodia of 10th and 22nd setigers (figs 38, 39) with small rounded preacicular notopodial lamella and supra-acicular lobe, postacicular lamella divided into two unequal lamellae, dorsal lamella the larger; neuropodium with divided preacicular lamella, consisting of small rounded median lamella and inferior digitate lobe, acicular lobe extending beyond preacicular lamella and with slight posterior



Figs 36-40. *Nephtys semiverrucosa* n.sp.: 36, ant. end, pharynx everted (dorsal view, x 70); 37, first setiger, (R, dorsal view, x 160); 38, tenth setiger (L, ant. view, x 160); 39, twenty-second setiger (R, ant. view, x 160); 40, forty-fifth setiger (L, ant. view, x 160).

expansion, postacicular lamella and ventral cirrus large, lamellate; interramal cirrus well-developed, partially ciliated together with parts of the epithelium of the interramal region. Parapodia of 45th setiger (fig. 40) with considerably reduced postacicular lamellae, acicular lobes extending beyond postsetal lobes, small globular dorsal and ventral cirri.

Setae of four kinds: narrow-winged, smooth-tipped capillaries, barred, spinose and spinulose (Table 7). Preacicular notosetae of setigers 1-9 dominated by barred setae, 6-10 per setiger, gradually replaced by straight spinulose setae. Postacicular notosetae capillary in setigers 1-2, subsequently spinulose and spinose, with spinose setae rapidly predominating. Preacicular neurosetae capillary in setiger 1, subsequently barred, spinose and spinulose, with barred setae disappearing by 28th neuropodium. Postacicular neurosetae spinulose and spinose, with spinose setae dominating.

REMARKS: *Nephtys semiverrucosa* n.sp. closely resembles the widely-distributed *N. australiensis* in possessing a supra-acicular lobe, parapodial lobes of similar proportions, and branchiae starting on the fourth setiger. The main difference lies in the ornamentation of the pharynx. *N. semiverrucosa* n.sp. lacks a median dorsal subdistal papilla, has a smooth mid-proximal ring and a proximal ring with verrucae, whereas *N. australiensis* has a median dorsal subdistal papilla and has the proximal surface completely covered in verrucae even in very small individuals (less than 15mm in length). Using these features, *N. semiverrucosa* n.sp. can be separated from *N. gravieri*, which also lacks a median dorsal subdistal papilla on the pharynx, but has the proximal surface completely covered with verrucae. *N. longipes*, a species commonly found in sandy areas, can be distinguished by the shape of the prostomium. Other species of *Nephtys* have interramal cirri commencing on setigers other than the fourth, and differ in the shape of their parapodia. The specific name refers to the position of the verrucae on the pharynx which are restricted to the basal region.

DISTRIBUTION: Australia (fig. 43).

ECOLOGY: Intertidal, in sand.

DISCUSSION

The four known genera of nephtyids are represented in Australian waters by 13 species, seven of which belong to the genus *Nephtys*. Additional records are likely, particularly in N.W. Australia and offshore around the coast of Australia, where almost no collecting has been done. The majority of Australian records of nephtyids are from intertidal or shallow subtidal areas; there are three deep water species, *Aglaophamus gippslandicus* n.sp. (fig. 41), *A. profundus* n.sp. (fig. 41), and *Nephtys paradoxa* (fig. 43), but they are numerically poorly represented in museum collections. The nephtyid fauna has a strong degree of endemicity, with only four species recorded from outside Australia; *N. paradoxa*, which appears cosmopolitan in its distribution, *A. dibranchis* and *A. verrilli*, which are recorded elsewhere in the Indo-Pacific, and *Micronephthys sphaerocirrata*, which has been recorded from the Gulf of Iran and S. Africa. *Nephtys australiensis* (fig. 42) is the dominant species along the east coast of Australia and occurs from intertidal to subtidal areas, in bays, estuarine areas and shallow coastal lagoons which are subjected to fluctuating salinities. This species is found in seagrass beds of *Zostera* and *Posidonia* and in sandy, muddy flats. In Western and South Australia, *N. australiensis* appears to be replaced by *N. gravieri* (fig. 43), which is also tolerant of fluctuating salinities. Two other species have similar distributions to *N. australiensis*,

Table 7. Nephtys semiverrucosa n.sp. — setal formulae of setigers 1, 10, 20 and 40, expressed as in Table 1.

Setiger	Setal Type			
	Barred	Spinulose	Spinose	Capillary
1	9 | — / —	— | — / —	— | — / —	— | 6 / 8
10	4 | — / 2 | —	1 | 5 / 1 | 5	— | 7 / — | 8	— | 1 / — | —
20	1 | — / 2 | —	4 | 5 / 5 | 7	— | 8 / — | 6	— | — / — | —
40	— | — / 1 | —	7 | 6 / 7 | 9	— | 7 / — | 9	— | — / — | —

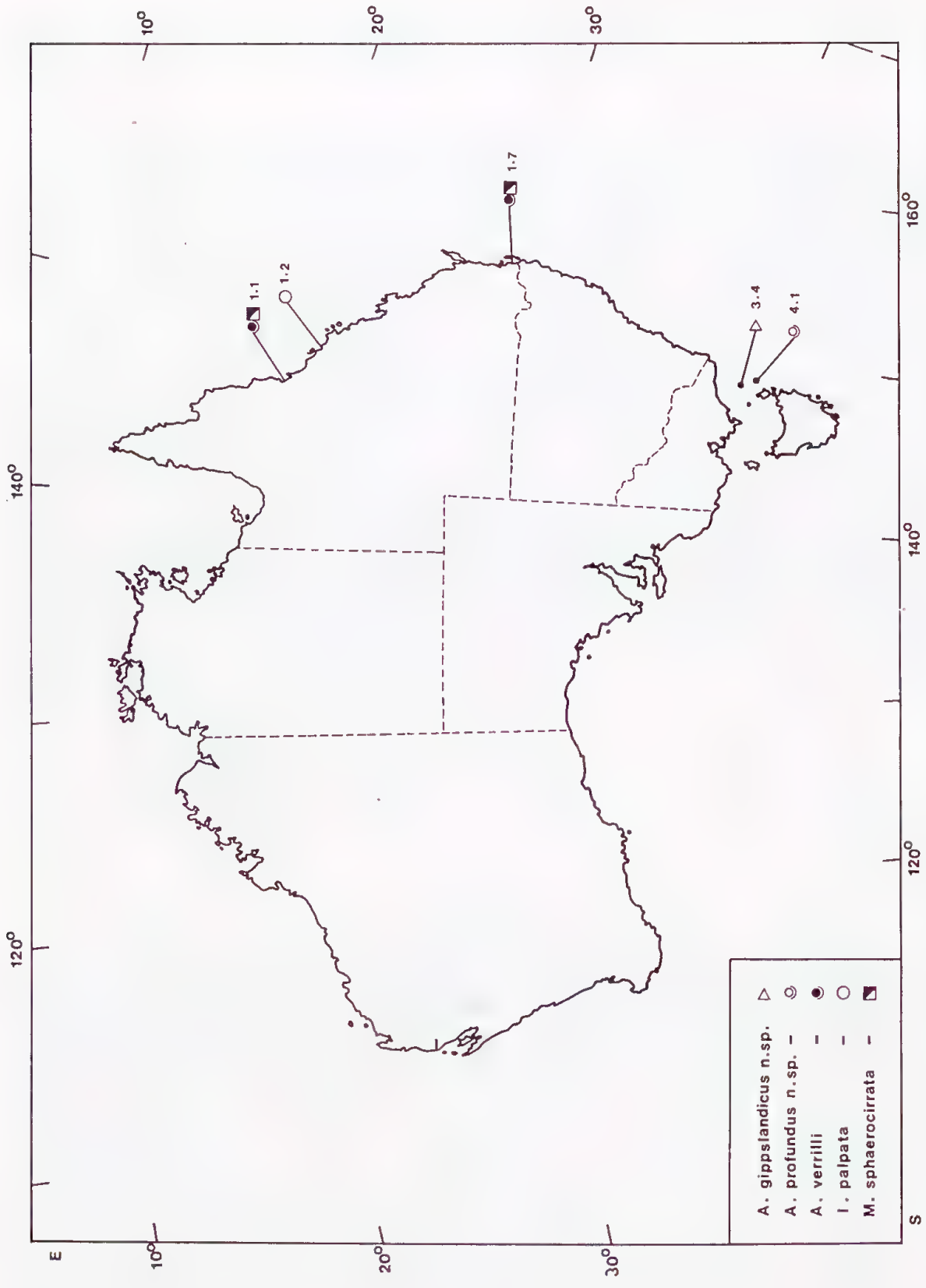


Fig. 41. Australian records for *Aglaophamus gippslandicus* n.sp., *A. profundus* n.sp., *A. verrilli*, *Inermonephtys palpata* and *Micronephthys sphaerocirrata*.

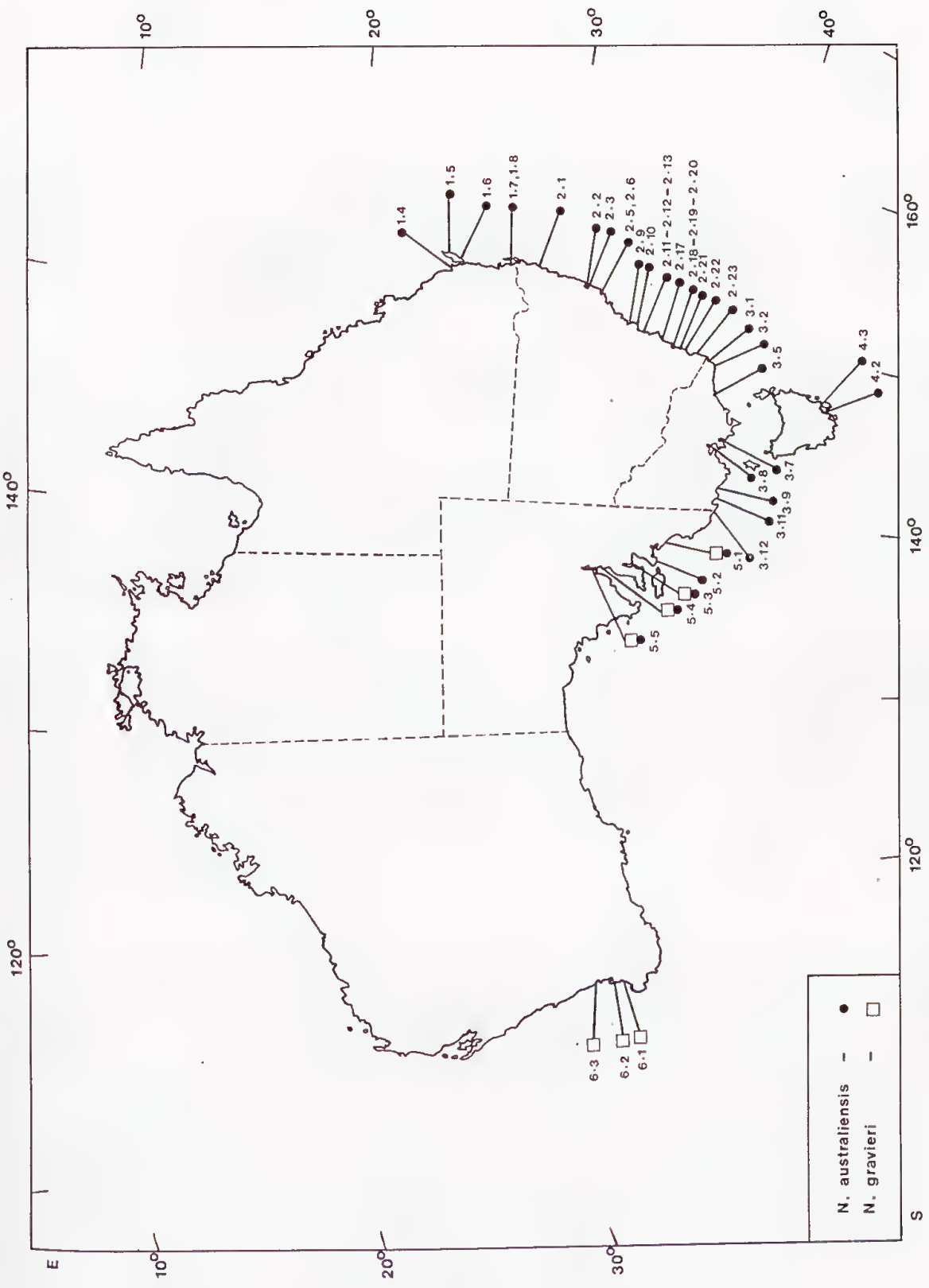


Fig. 42. Australian records for *Nephtys australiensis* and *N. gravieri*.

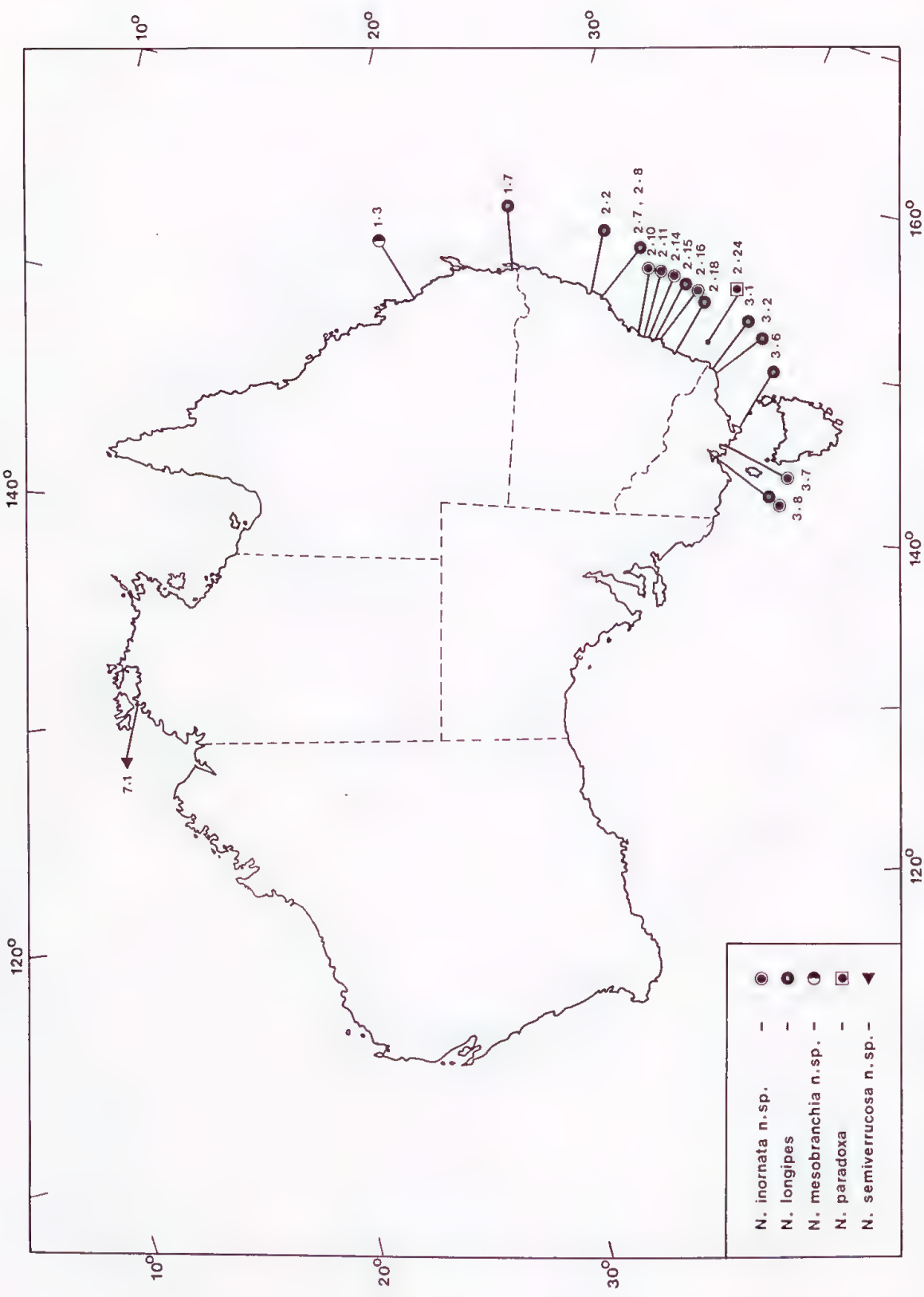


Fig. 43. Australian records for *Nephtys inornata* n.sp., *N. longipes*, *N. mesobranchia* n.sp., *N. paradoxa* and *N. semiverrucosa* n.sp.

although occurring in slightly different habitats; *N. longipes* (fig. 43) and *N. inornata* n.sp. (fig. 42) live in sheltered but fully marine situations, *N. longipes* in clean sand and *N. inornata* in sandy mud; both species occur in intertidal and shallow subtidal areas. *Nephtys longipes* and *N. australiensis* extend into southern Queensland, but have not been found north of Hervey Bay. *Nephtys mesobranchia* n.sp. (fig. 43) may replace *N. australiensis* above this latitude but so far it has only been recorded from the Calliope R., Gladstone, in an estuarine situation with fluctuating salinities. Unfortunately, very little intertidal or estuarine collecting has been done north of Gladstone. *Aglaophamus verrilli* (fig. 41) and *N. sphaerocirrata* (fig. 41) have been found in subtidal areas in Moreton Bay and off Townsville, in somewhat sheltered muddy situations, during extensive environmental surveys carried out in these areas. No other offshore surveys have been carried out between these two localities, and these species probably have a more continuous distribution.

In differentiating closely-related species, we found useful several characters to which insufficient attention has often been paid in earlier descriptions. These are the distribution of verrucae on the pharynx, the distribution and abundance of the various kinds of setae, and the shape and size of parapodial lamellae along the entire length of the body. We have also noticed that within a species there can exist some variation in the size and shape of parapodial lamellae and interramal cirri, in the distribution of setae and in pigmentation patterns, but there is little variation in the qualitative ornamentation of the pharynx. The variation found may be a function of size or related to the environment. In *Nephtys australiensis,* with abundant material available for study, variation in the number of barred setae was mainly size-related, while the size of interramal cirri appeared to be environmentally-related.

The use of the terms spinose and spinulose is not intended to imply a qualitative difference in spination, but rather to indicate consistent differences in the size and strength of setal spines that are useful in identification. We have looked at the setal spines of *N. australiensis* with a scanning electron microscope and have confirmed the light microscope picture that spines near the base of a seta tend to be arranged in closely set transverse rows. With the light microscope, spines towards the tip of a seta appear randomly organised; SEM examination showed no difference in the arrangement of spines along the length of a seta, the number and size of spines in each transverse row being gradually reduced towards the setal tip.

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A REVISION OF THE DAMSELFISH GENUS *DASCYLLUS* (POMACENTRIDAE) WITH THE DESCRIPTION OF A NEW SPECIES

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SUMMARY

The damselfish genus *Dascyllus* (family Pomacentridae) is reviewed. The group contains the following nine species which are primarily inhabitants of tropical reefs: *albisella* (Hawaiian Islands), *aruanus* (widespread Indo-Pacific), *carneus* (Indian Ocean), *marginatus* (Red Sea), *melanurus* (Indo-Australian Archipelago), *reticulatus* (E. Indian Ocean and W. Pacific), *strasburgi* (Marquesas Islands), *trimaculatus* (widespread Indo-Pacific), and *flavicaudus* n.sp. (southeastern Oceania) which is described in detail and compared with its nearest relative, *D. reticulatus*. A brief diagnosis, illustration, and notes on the general biology of each species is provided. In addition, a key to the species of *Dascyllus* and tables of meristic and morphometric data are included.

INTRODUCTION

The present paper is part of a series of generic revisions of the Pomacentridae currently in progress by the junior author; either alone or in conjunction with various colleagues. The need for revision of certain problem genera in this speciose family of tropical reef fishes was discussed previously by Allen and Robertson (1974), Allen (1975), and Allen and Lubbock (1976).

The genus *Dascyllus* Cuvier (1829) contains nine species which inhabit the vast tropical region of the Indo-West Pacific. The genus has not been reviewed previously on a comprehensive basis although it has been treated by authors of large monographic works and regional faunal volumes or reports. Cuvier (1830) recognized three species: *aruanus* (Linnaeus), *marginatus* (Rüppell), and *trimaculatus* (Rüppell). Günther (1862) also placed these three species in the genus along with five others: *albisella* Gill, *melanurus* Bleeker, *xanthosoma* Bleeker, *polyacanthus* Bleeker, and *cyranurus* (Rüppell). However, the latter two do not belong in *Dascyllus* as presently defined and are allocated as follows: *cyranurus* = *Chromis caerulea* (Cuvier); *polyacanthus* = *Acanthochromis polyacanthus*. Furthermore, Bleeker's *xanthosoma* is a synonym of *D. reticulatus* described by Richardson in 1846. Bleeker's (1877) review of the pomacentrids of the East Indies included four species: *arcuatum* (= *aruanus*), *melanurus*, *reticulatum*, and *trimaculatum*; these have been considered as valid entities by most subsequent authors, in addition to *D. marginatus* from the Red Sea and *D. albisella* from the Hawaiian Islands. All of these except *marginatus* were included in Allen's (1975) synopsis of western Pacific pomacentrids. In addition, he recognized *D. strasburgi* Klausewitz, a species described relatively recently from the Marquesas Islands. Smith (1960) in his review of the pomacentrid fishes of the western Indian Ocean placed *D. carneus* Fischer in the synonymy of *D. reticulatus*, but the present study indicates that the former species is valid. *D. flavicaudus* n.sp., the final member of the group, is described below from a series of specimens obtained mainly by Dr. J. E. Randall during a cruise to southeast Oceania abord the sailing ship "Westward" during 1970-71.

Records of The Australian Museum, 1977, **Vol. 31, No. 9,** 349-385, Figures 1-11.

In addition to *polyacanthus* and *cyanurus,* five other species have been erroneously described as members of *Dascyllus: xanthurus* Bleeker = *Neopomacentrus violascens* (Bleeker); *fasciatus* Macleay = *Dischistodus fasciatus* (Cuvier); *pomacentroides* Kendall and Goldsborough = *Chromis lepidolepis* Bleeker; *caudofasciatus* Montalban = *Chromis lepidolepis; isharae* Schmidt = *Chromis chrysura* (Bliss). Whitley (1928) described *Tetradrachmum* (a synonym of *Dascyllus*) *nitidum,* but this species is currently recognized as a valid *Chromis.*

The junior author has observed all the members of the genus except *D. strasburgi* in their natural habitat on various diving and collecting trips to Hawaii, Tahiti, Java, Ceylon, Red Sea, and numerous localities in the western Pacific and Australia. This experience has given us an appreciation of the limits of variability, particularly with regards to colour pattern and has aided us in making difficult taxonomic decisions regarding the status of *D. albisella* and *D. strasburgi* which are obviously offshoots of *D. trimaculatus* ancestral stock.

The members of the genus typically form small to large aggregations in rocky or coraliferous areas. Several of the species aggregate around isolated coral heads where they seek shelter at night or when danger threatens during the day. Sale (1971a) and others have described the permanent nature of these aggregations. The diet consists of a variety of planktonic items with copepods frequently composing the dominant food source. Feeding occurs during most of the daylight hours up to several metres off the bottom with the members of the aggregation facing the oncoming current. *D. aruanus* and *D. melanurus* prefer relatively shallow, protected waters such as those found within the lagoons of oceanic atolls or inside coastal fringing reefs. The remaining species are relatively ubiquitous with regards to vertical distribution and also occur in passages leading to the open sea and on the outer reef slope down to at least 55 metres.

The general behaviour of *Dascyllus,* highlighted by a limited territoriality or home range and relatively stereotyped sequence of courtship and spawning activities, and subsequent nest guarding by the male conforms to the typical pomacentrid pattern described by Reese (1964). More detailed data on these subjects are included below under the biology section for each species.

METHODS OF COUNTING AND MEASURING

The methods of counting and measuring are basically the same as those described by Allen (1972), but several terms require further explanation. Snout length is measured from the anterior edge of the upper lip to the nearest point on the orbit; predorsal length is from the snout tip to the base of the the first dorsal spine; preanal and prepelvic lengths are similar measurements connecting the snout tip with the base of the first anal spine and pelvic spine respectively; dorsal and anal fin rays were measured proximally from the base of the spine or soft ray rather than the point at which the element emerges from the scaly sheath; tubed lateral-line scales refer to the continuous series of sensory scales on the upper back originating near the upper edge of the gill opening, this count excludes the scales with simple pits or pores which sometimes appear at the end of the tubed section and also excludes the series of sensory scales (usually 5 to 9 in number) mid-laterally on the caudal peduncle; caudal fin length is measured from the line of flexure at the base of the fin to the distal tip of the longest ray of the upper lobe; caudal concavity is the horizontal distance between the longest and shortest caudal rays. Measurements were made with dial calipers to the nearest one-tenth mm. The length which is given in mm under the material examined sections and elsewhere in the text refers to the standard length.

The counts and proportions which appear in parentheses in the description of *D. flavicaudus* represent the range for the paratypes if differing from the holotype. A summary of counts for the dorsal, anal, and pectoral fin rays, tubed lateral-line scales, and gill rakers on the first arch is presented in Tables 1 and 2.

During the course of our investigations we have examined all *Dascyllus* specimens from the following institutions (abbreviations indicated are used in subsequent text): American Museum of Natural History, New York; Australian Museum, Sydney (AMS); Academy of Natural Sciences, Philadelphia; British Museum (Natural History), London (BMNH); Bernice P. Bishop Museum, Honolulu (BPBM); California Academy of Sciences, San Francisco (CAS); Field Museum of Natural History, Chicago; Museum of Comparative Zoology, Harvard University; Museum National d'Histoire Naturelle, Paris (MNHN); Queensland Museum, Brisbane (QM); Rijksmuseum van Natuurlijke Histoire, Leiden (RMNH); Natur-Museum Senckenberg, Frankfurt (SMF); United States National Museum of Natural History, Washington, D.C. (USNM); Western Australian Museum, Perth (WAM); Zoologisch Museum, Amsterdam. The total number of specimens examined in more detail (counts or proportions taken) is indicated for each species in the material examined section.

TAXONOMY

Dascyllus Cuvier

Dascyllus Cuvier, 1829: 179 (type species, *Chaetodon aruanus* Linnaeus, by monotypy).

Pirene Gistel, 1848: ix (substitute name for *Dascyllus* Cuvier).

Tetradrachmum Cantor, 1850: 1222 (substitute name for *Dascyllus* Cuvier).

Pellochromis Fowler and Bean, 1928: 14 (type species, *Pomacentrus trimaculatus* Rüppell, by original designation).

Semadascyllus Fowler, 1941: 257 (type species, *Dascyllus albisella* Gill, by original designation.)

DIAGNOSIS: A member of the pomacentrid subfamily Chrominae with the following combination of characters: dorsal rays XII,11 to 16; anal rays II,11 to 15; pectoral rays 17 to 21; tubed lateral-line scales 15 to 20; gill rakers on first arch 5 to 8 + 15 to 23; teeth conical, relatively large at front of jaws and tapering in size posteriorly, a patch of small villiform teeth behind larger teeth at front of jaws, outer row teeth usually numbering about 36 to 44 in each jaw; margin of preorbital, suborbital, and preoperculum finely serrate; opercle bones with hind margin smooth to weakly serrate or crenulate; head entirely scaled except lips and isthmus; double nostril openings connected by shallow naked groove on each side of snout, anterior opening round and conspicuous, posterior opening an inconspicuous slit next to orbital rim; spiniform procurrent rays at dorsal and ventral base of caudal fin 2.

Juvenile specimens are excluded in the following proportional data (see size range under diagnosis section for each species). Body relatively orbiculate, deep for the family, the greatest depth 1.4 to 1.7 in the standard length; head relatively short, its length 2.7 to 3.6 in the standard length; snout length 2.9 to 4.4, eye diameter 2.1 to 3.2, interorbital width 2.4 to 3.5, least depth of caudal peduncle 1.6 to 2.1, length of caudal peduncle 2.3 to 4.5, of pectoral fin 0.9 to 1.3, of pelvic fin 0.8 to 1.1, of caudal fin 0.8 to 1.2, caudal concavity 2.0 to 11.1, all in head length. Maximum size ranges from about 50 mm in *D. carneus* and *D. marginatus* to about 100 to 120 mm for *D. trimaculatus*.

REMARKS: Gistel (1848) introduced the name *Pirene* as a substitute for *Dascyllus* thinking that the latter name was preoccupied by *Dascillus* Latreille a genus of *Coleoptera* described in 1796. However, according to the International Code of Zoological Nomenclature (article 56a) "even if the difference between two genus-group names is due to only one letter, these two names are not to be considered homonyms." Moreover, *Pirene* Gistel itself is considered by some authors (see Whitley, 1929) to be preoccupied by *Pyrene* Bolton, a genus of molluscs. It was this logic which prompted Cantor (1849) to introduce another substitute name, *Tetradrachmum,* which has enjoyed relatively widespread use, particularly among certain Australian and Japanese authors.

Fowler and Bean (1928) established the subgenus *Pellochromis* for *D. trimaculatus* and *D. reticulatus* (referred to as *marginatus* by these authors). They based this division on colour pattern, more specifically due to the presence of a dark or dusky ground colour without transverse black bands. Similarly, Fowler (1941) placed *D. albisella* in *Semadascyllus* which he distinguished from *Pellochromis* "chiefly by the greatly elevated first dorsal fin and very long ventrals." We do not consider these characters to be useful ones. Fowler's specimens were juveniles which characteristically have large fins in relation to overall body size. We prefer to avoid subgeneric divisions in this relatively close-knit genus.

KEY TO THE SPECIES OF *DASCYLLUS*

1a. Soft dorsal rays usually 12 (rarely 11 or 13); colour of head and body pale with three black bars 2

1b. Soft dorsal rays 14 to 16; colour not as in 1a 3

2a. Caudal fin pale; soft anal rays usually 12 (rarely 11 or 13) (Indo-W. Pacific) ..... *aruanus* (Linnaeus)

2b. Caudal fin dark on outer half; soft anal rays usually 13 (occasionally 12) (E. Indies, Philippines, Melanesia, Queensland, Caroline Islands) ..... *melanaurus* Bleeker

3a. Gill rakers on lower limb of first gill arch usually 16 to 18; preserved coloration generally brown to blackish, most scales of body with darker marginal band; frequently with strongly contrasted pale spot on upper portion of side or on forehead, especilly in smaller (less than about 50 mm) specimens; no black bar extending from dorsal fin origin to pelvic base; one or more relatively well developed tubed scales mid-laterally on caudal peduncle 4

3b. Gill rakers on lower limb of first gill arch usually 18 to 23; preserved coloration generally pale tan to brown with or without darker scale margins; strongly contrasted pale spot on upper side and forehead absent; black bar frequently extending from dorsal fin origin to pelvic base and second bar sometimes present immediately anterior to caudal peduncle; lateral-line tubes absent on caudal peduncle, instead grooves, pits, or pores present on mid-lateral scales 6

4a Soft dorsal rays usually 16 (occasionally 15); soft anal rays usually 15 (occasionally 14) (Hawaiian Islands) ..... *albisella* Gill

4b. Soft dorsal rays usually 15 (occasionally 14 or 16); soft anal rays usually 14 (rarely 15) 5

5a. Preserved colour generally dark brown to blackish; fins usually dark or if fins pale at least outer 1/3 of spinous dorsal black (Indo-W. Pacific) ..... *trimaculatus* (Ruppell)

5b. Preserved colour generally tan to brown; fins pale to dusky, outer 1/3 of spinous dorsal pale (Marquesas Islands) ..... *strasburgi* Klausewitz

6a. Head and body mostly without dark markings (in preservative) except most scales of side frequently with dusky streak and large black spot covering pectoral base; pectoral rays usually 18 or 19 (Red Sea and Gulf of Oman) *marginatus* (Rüppell)

6b. Head and body frequently with black bar extending from dorsal fin origin to pelvic base and second bar sometimes present immediately anterior to caudal peduncle (these may be faint and difficult to detect in certain preserved specimens); scales of body usually with dusky margin; black spot at pectoral base relatively small and confined to base of uppermost one or two rays; pectoral rays usually 20 or 21 (rarely 19) 7

7a. Small dark-rimmed spots (blue in life) present on head and breast, approximately one spot per scale in these regions; gill rakers on lower limb of first gill arch usually 18 (occasionally 17 or 19, rarely 20) (Indian Ocean and Java Sea near Sunda Straits) ..... *carneus* Fischer

7b. Small dark-rimmed spots on head and breast absent; gill rakers on lower limb of first gill arch usually 19 to 22 (most frequently 20 or 21, rarely 18) 8

8a. Soft anal rays usually 13 (occasionally 14); posterior edge of anal fin pale, maximum size of adults 60-65 mm (E. Indian Ocean and W. Pacific) ..... *reticulatus* (Richardson)

8b. Soft anal rays usually 14 (occasionally 13); anal fin entirely dark; maximum size of adults 90-100 mm (southeastern Oceania) ..... *flavicaudus* n.sp.

SPECIES ACCOUNTS

Dascyllus aruanus (Linnaeus) Fig. 1

Chaetodon aruanus Linnaeus, 1758: 275 (type locality, Indies).

Chaetodon arcuanus Gmelin, 1789: 1250 (revival of name used by Linnaeus before 1758).

Pomacentrus emamo Lesson, 1830: 190 (type locality, Bora Bora, Society Islands).

Tetradrachmum arcuatum Cantor, 1849: 1223 (type locality, Penang).

Dascyllus blochii Castelnau, 1875: 34 (type locality, Queensland).

Pomacentrus trifasciatus De Vis, 1884: 452 (type locality, South Seas).

Pomacentrus devisi Jordan and Seale, 1906: 284 (substitute name for *Pomacentrus trifasciatus* De Vis).

Abudefduf caroli Curtiss, 1938: 117 (type locality, Tahiti).

DIAGNOSIS: (Proportions based on 30 specimens, 43-57 mm). Dorsal rays usually XII,12; anal rays usually II,12; pectoral rays usually 18; tubed lateral-line scales usually 17 or 18; gill rakers on first arch usually 6 or 7 + 16 or 17; greatest depth of body 1.5 to 1.7, head length 2.9 to 3.1, both in standard length; snout length 3.4 to 4.4, eye diameter 2.5 to 3.0, interorbital width 3.0 to 3.5, least depth of caudal peduncle 1.8 to 2.0, length of caudal peduncle 2.3 to 2.8, of pectoral fin 1.0 to 1.1, of pelvic fin 0.9 to 1.0, of caudal fin 0.8 to 1.0, caudal concavity 2.0 to 3.2, all in head length.

Fig. 1. *Dascyllus aruanus*, approximately 50 mm, Palau Islands in 5 metres depth.

Colour in life: live coloration was illustrated by Allen (1975) and consists of the following pattern: ground colour white with three highly contrasted black bars (see Fig. 1 for position of bars); large pale brown spot covering dorsal portion of snout and interorbital; lips dusky or white; dorsal fin largely covered by continuation of black body bars, except base of spines 2-5 and base of last few spines white, soft dorsal fin transparent on posterior edge; caudal fin mainly transparent, sometimes dusky; anal fin mostly covered by continuation of third black body bar except base of anterior portion white and posterior edge transparent; pelvic fins black; pectoral fins transparent.

Colour in alcohol: similar to live coloration except white ground colour sometimes grey to yellowish or with dusky blotches.

RANGE: Widespread in the Indo-W. Pacific from the Red Sea and east African coast as far south as Durban to the central and western Pacific as far north as southern Japan and south to the Sydney area of Australia; the Line Islands, Marquesas, and Tuamotu Archipelago form the eastern limit of distribution.

BIOLOGY: This species inhabits lagoons and coastal reefs, usually in one to 12 metres depth. It commonly forms aggregations of up to 30 fish which shelter among branched madreporarian corals. The favoured habitat is areas of interspersed sand and coral patches. The diet consists largely of zooplankton and feeding occurs in the water column one or two metres above the coral. Hiatt and Strasburg (1960) listed the following dietary items for *D. aruanus:* copepods, larvae of crustaceans, fishes (gobiids), and fish eggs.

Fortunately, this species has been the focus of several ecological and behavioural investigations. Sale (1970; 1971a & b; 1972a & b) has written a series of papers describing the behaviour of this species in relation to its extremely limited home range which is usually centred on a single coral colony. He observed a hierarchal social structure within each group of fish. This structure was elucidated by Fricke and Holzberg (1974) in their study of 80 aggregations of *D. aruanus* in the Gulf of Aquaba, Red Sea. They found that 38% of the fish in these groups lived in heterosexual pairs, 56% in aggregates of three to six, and 6% in groups of more than six fish. Long term observations of several groups containing three to six fish indicated a harem-type social structure containing a single dominant male (70-80 mm total length) and several females (20-70 mm) with linear size dependent rank order. These authors found that the dominant male spawned with the females in order of rank and also attempted to mate females from nearby territories. The home territory is defended against potential egg predators and other *Dascyllus* primarily by the male and largest female. Gonad examination of a colony of 11 fish revealed one large male, eight females, and two hermaphrodites. Fricke and Holzberg suggest that sex reversal probably occurs in this species and could be a mechanism which would allow young immigrating males to be incorporated in the rank system of large groups. They interpret the different social units of *Dascyllus* as ecological adaptations.

The reproductive behaviour of *D. aruanus* has been described by Chlupaty (1957), Fishelson (1964), and Sale (1970). The male selects a nest site usually near the base of the coral colony and removes some of the algal growth and detritus. Throughout the period of nest preparation, which may last one day or more, the male spends a great deal of time chasing other fishes away from the site and also initiates a characteristic courtship "dance", which consist of a series of rapid up and down swimming movements performed about one metre above the nest. Gravid females are attracted to the display and subsequently are escorted to the nest site where spawning ensues. A single male may spawn with several females, with each depositing up to 1500-2000 elliptical eggs, 0.7-0.8 mm in length.

The male aggressively guards the nest during incubation and actively fans the eggs with the pectoral fins and also "cleans" the site orally. Hatching occurs at 24°-25°C in 44-51 hours. The fry are approximately 2 mm total length at hatching and are presumed to be pelagic for an undetermined period. The smallest individuals residing on coral reefs are about 8 mm total length. Catala (1971) reported several individuals of *D. aruanus* which had been living in the Noumea Aquarium for six years. The same fish were observed three years later by the junior author, indicating a longevity of at least nine years in captivity.

MATERIAL EXAMINED: We have examined more than 400 specimens, 10-65 mm, from the following localities: Red Sea; Kenya; Zanzibar; Amirante Islands; Farquhar Islands; Aldabra Atoll, Madagascar, Mauritius, St. Brandon's Shoals (Cargados Carajos), Maldive Islands, Nicobar Islands, Mentawei Islands (Sumatra), Java, Okinawa, Philippine Islands, Australia, Lord Howe Island, Caroline Islands, Mariana Islands, Marshall Islands, New Guinea, Solomon Islands, New Hebrides, Gilbert Islands, Fiji Islands, Samoa Islands, Tokelau Islands, Phoenix Islands, Line Islands, Society Islands, Tuamotu Islands, Marquesas Islands and Rapa Island. These localities have been reported by previous authors, most of them by either de Beaufort (1940), Smith (1960) or Allen (1975). Smith, however, in reporting the species from the western Indian Ocean did not mention specific localities, merely stating it occurred over the entire region.

We have not examined the type of *aruanus* (presumably deposited at Naturhistoriska Riksmuseet, Stockholm), but there is no doubt about the identity of this species as the description was based on the specimen which was illustrated by Linnaeus (1754). We have examined a copy of this important "pre-Linnaean" work and find the illustration (plate 33, figure 8) of *Chaetodon arcuatus* to be clearly diagnostic.

Castelnau (1875) gave a brief diagnosis of *D. aruanus*. He mentioned that a young Queensland specimen had a rounded instead of bifid tail, suggesting that the shape might be correlated with age. He gave this form the name *blochii* in the event that it might prove to be distinct. The type specimen is apparently no longer in existence (we have checked the MNHN collection), but it is obvious this species should be placed in the synonymy of *D. aruanus*. It seems likely that the caudal fin of Castlenau's specimen was damaged.

The type of *Pomacentrus trifasciatus* De Vis (1884) is apparently missing. It is not among other De Vis types presently lodged at the Queensland Museum. However, the brief colour description and dorsal ray count indicate that this species is a synonym of *D. aruanus*. Somewhat confusing is the soft anal ray count which was given as four, far lower than any known species in the family. We suspect this figure respresent either an error or was based on an aberrant or damaged specimen.

We follow Fowler (1949) in placing *Abudefduf caroli* Curtiss in the synonymy of *D. aruanus*. According to him, the work (Curtiss, 1938) in which the description appears was privately printed in a limited edition and "reveals the efforts of an untrained novice." Apparently no type specimens were designated.

Dascyllus melanurus Bleeker Fig. 2

Dascyllus melanurus Bleeker, 1854: 100 (type locality, Neira, Banda).

Pomacentrus onyx De Vis, 1844: 451 (type locality, South Seas).

DIAGNOSIS: (Proportions based on 18 specimens, 35-61 mm). Dorsal rays usually XII,12; anal rays usually II,13; pectoral rays usually 18; tubed lateral-line scales usually 16

Fig. 2. *Dascyllus melanurus*, 37 mm, Philippine Islands (J. Randall photo).

or 17; gill rakers on first arch usually 6 or 7 + 17 to 19; greatest depth of body 1.5 to 1.7, head length 2.7 to 3.1, both in standard length; snout length 3.4 to 4.3, eye diameter 2.3 to 3.2, interorbital width 2.7 to 3.3, least depth of caudal peduncle 1.8 to 2.1, length of caudal peduncle 2.3 to 2.7, of pectoral fin 1.0 to 1.2, of pelvic fin 0.8 to 1.1., of caudal fin 1.0 to 1.2, caudal concavity 3.5 to 6.0, all in head length.

Colour in life: live coloration was illustrated by Allen (1975) and consists of the following pattern: ground colour white with three highly contrasted black bars (see Fig. 2 for position of bars); dorsal fin largely covered by continuation of black body bars, except middle portion white and posterior edge of soft dorsal transparent; caudal fin mostly black except basal ⅓ white; anal fin mostly covered by continuation of third black body bar except base of anterior portion white and posterior edge transparent; pelvic fins black; pectoral fins transparent.

Colour in alcohol: similar to live colouration except white ground colour sometimes grey to yellowish or with dusky blotches.

RANGE: The distribution includes the islands of Indonesia from Sumatra to West Irian, Philippine Islands, New Guinea, northern Great Barrier Reef of Australia, New Britain, Solomon Islands, New Hebrides, New Caledonia, Palau Islands, Yap Islands and Ponape. Regan (1908) also reported the species from Felidu, Maldive Islands. This is the only record west of the Indonesian Archipelago. Apparently it is rare in the Maldives; large collections from there made by Loren P. Woods and Wolfgang Klausewitz failed to obtain further specimens.

BIOLOGY: This species inhabits sheltered lagoons, harbours, and coastal inlets, usually in one to 10 metres depth. It commonly occurs in aggregations containing 20-30 fish which are associated with isolated coral heads. The diet consists of a variety of planktonic items including larval shrimps, crabs, ostracods, amphipods, pelagic tunicates, copepods, and fish eggs. Some algae is also taken.

Nothing is known about the life history, but the general behaviour of this species is similar to the closely related *D. aruanus*.

MATERIAL EXAMINED: We have examined 115 specimens, 18-61 mm, from the following localities: Indonesia, Philippine Islands, New Guinea, Solomon Islands, New Hebrides, and Palau Islands. The New Hebrides specimen (WAM P25577-001) represents a new locality record.

In addition, we have examined the two remaining syntypes (of eight reported by Bleeker) of *D. melanurus* (RMNH 6452, approximately 41 and 45 mm; bad condition with missing caudal fins and heads detached) and also the lectotype of *Pomacentrus onyx* (QM I.11/99, 34 mm). The latter species was redescribed by Whitley (1929) who concluded it was a synonym of *D. melanurus*.

Dascyllus albisella Gill Fig. 3

Dascyllus albisella Gill, 1862: 149 (type locality, Hawaiian Islands).

Dascyllus edmondsoni Pietschmann, 1934: 100 (type locality, Oahu, Hawaiian Islands).

DIAGNOSIS: (Proportions based on 20 specimens, 58-87 mm). Dorsal rays usually XII, 15 or 16, anal rays usually II, 14 or 15; pectoral rays usually 20; tubed lateral-line scales usually 19; gill rakers on first arch usually 6 or 7 + 16 to 18; greatest depth of body 1.4 to 1.6, head length 3.1 to 3.2, both in standard length; snout length 3.2 to 3.7, eye diameter 2.3 to 2.7, interorbital width 2.8 to 3.1, least depth of caudal peduncle 1.7 to 1.9, length of

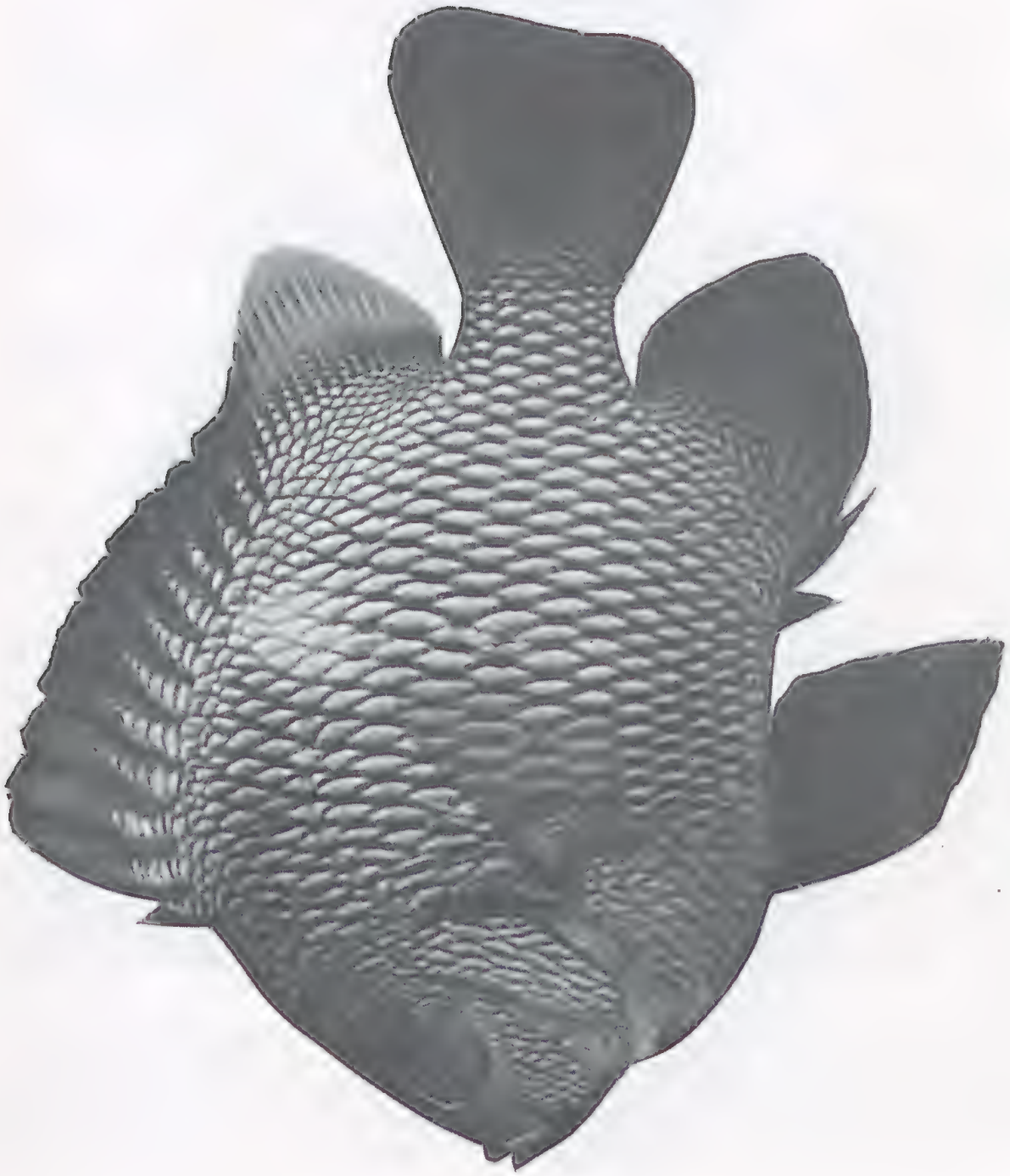

Fig. 3. *Dascyllus albisella*, 79 mm, Hawaiian Islands (J. Randall photo).

caudal peduncle 3.2 to 3.7, of pectoral fin 0.9 to 1.0, of pelvic fin 0.8 to 0.9 of caudal fin 0.9 to 1.1, caudal concavity 6.0 to 8.7, all in head length.

Colour in life: general coloration is similar to *D. trimaculatus* (see Chute, 1936). Juveniles are black with a large white spot on the middle of the upper back; an additional white spot is present on the forehead. These markings become less distinct with increased growth, the forehead spot generally disappearing in subadults. The adult pattern was illustrated by Allen (1975) and consists of a brownish head, ground colour of body whitish or grey and scales with blackish margins. The pectorals and outer half of the soft dorsal are primarily transparent; remainder of fins dark brown or black. In addition, there is usually a trace of the white spot on the upper sides, occupying about 7-9 scales mainly above the 10th-14th tubed lateral-line scales.

Variation in colour influenced by behaviour and ecology was discussed by Stevenson (1963a). He described the normal coloration as being dark (blackish), but turning paler in sandy environments or during feeding and nuptial activities.

Colour in alcohol: similar to that described below for *D. trimaculatus* except the light centres and dark margins of the body scales are generally more strongly contrasted in *albisella*.

RANGE: Known from the Hawaiian Islands and Johnston Island, which lies approximately 1,000 km south of the Hawaiian chain.

BIOLOGY: This species is relatively common in rocky areas to a depth of at least 46 metres. Juveniles are usually associated with small heads of *Pocillopora* coral or occasionally with the sand dwelling anemone, *Marcanthia cookei* (see Stevenson, 1963b).

The life history was studied by Stevenson (1963a). He noted that adults were often found near *Porites* coral and formed feeding aggregations of up to several hundred individuals. The fish feed 3-6 metres off the bottom, preferring planktonic items such as copepods, polychaetes, "larvaceans," and miscellaneous crustacea. Spawning occurs throughout the year with a peak of reproductive activity during June. Courtship and nesting habits are similar to *D. aruanus* and *D. carneus*. An average of 25,000 eggs are spawned by each female. These are very small, measuring .85 x .4 mm. The nest is guarded intensively by the male during the four day incubation period. Intruders are chased away from the site and this aggressive behaviour is often accompanied by loud grunting noises. At hatching the fry are 2.5 mm total length and are presumed to be pelagic for several weeks. The average size of colonising post-pelagic juveniles is about 15 mm total length. Stevenson found that young fish grew at a rate of about 5.1 mm per month and estimated that it takes one year to reach sexual maturity.

MATERIAL EXAMINED: We have examined 37 specimens, 18-97 mm, from Oahu and Hawaii, Hawaiian Islands. In addition, we have studied the three syntypes of *D. albisella*, 22-35 mm, which are deposited at USNM (register number 6274). Although we have not examined the type specimen, the detailed description of *D. edmondsoni* by Pietschmann (1934) clearly indicates it is a junior synonym of *D. albisella*.

Dascyllus trimaculatus (Rüppell) Figs 5 and 6

Pomacentrus timaculatus Rüppell, 1828: 39 (type locality, Massaua, Red Sea).

Pomacentrus nuchalis Bennett, 1830: 688 (type locality, Sumatra).

Dascyllus unicolor Bennett, 1831: 127 (type locality, Mauritius).

Fig. 4. *Dascyllus trimaculatus*, "normal" variety, 105 mm, Tahiti (J. Randall photo).

Fig. 5. *Dascyllus trimaculatus*, "intermediate" variety, approximately 60 mm, Fiji Islands in 6 metres depth.

Dascyllus niger Bleeker, 1847: 10 (type locality, Java).

Dascyllus axillaris Smith, 1936: 205 (type locality, South Africa).

DIAGNOSIS: (Proportions based on 30 specimens, 54-100 mm). Dorsal rays usually XII, 15; anal rays usually II, 14; pectoral rays usually 19 or 20; tubed lateral line scales usually 18 or 19; gill rakers on first arch usually 6 or 7 + 17 or 18; greatest depth of body 1.4 to 1.6, head length 3.1 to 3.6, both in standard length; snout length 2.9 to 3.7, eye diameter 2.3 to 3.1, interorbital width 2.5 to 3.0, least depth of caudal peduncle 1.6 to 1.8, length of caudal peduncle 2.4 to 3.1, of pectoral fin 0.9 to 1.1, of pelvic fin 0.8 to 1.0, of caudal fin 0.9 to 1.1, caudal concavity 5.3 to 11.1, all in head length.

Colour in life: juveniles and adults were illustrated by Allen (1972 and 1975). The young are overall black with lighter (bluish) scale centres; prominent white blotch present on forehead and upper sides (bisected by about 10-13th tubed lateral-line scales); all fins black except pectorals and outer half of soft dorsal transparent. Adults are variable in colour according to behavioural "mood" and ecological conditions, but generally lack the forehead spot and have the spot on the upper sides very much reduced, covering only about 1 or 2 scales above the 10th-13th lateral-line scale; in juveniles this spot covers as many as 10-15 scales and extends below the lateral-line. The detailed structure of this spot was described by Amemiya and Hiyama (1941). The head and fins are normally black (sometimes suffused with reddish-brown) and the scales of the body possess black margins; centre of body scales range from dark grey to pale bluish grey. Lighter colours are generally exhibited by fish which are feeding or by males in courtship. As in juveniles all fins are usually black except the transparent pectorals and outer portion of the soft dorsal. However, a peculiar variation exists in some areas which has the pelvic, anal, and caudal fins orange and also this colour may extend on to the abdomen, breast, and lower portion of the head. In addition, there is a row of elongate orange "windows" which occupy the middle portion of the spinous dorsal fin.

Observations by the junior author indicate that the orange-finned variety is correlated with an environment characterised by relatively turbid water and heavy silting. Allen (1975) illustrated a subadult which was intermediate between normal *trimaculatus* and the orange-finned variety. It was photographed (see Fig. 6) off Suva, Fiji Islands in an area of mild turbidity and silting. We have examined the orange-finned variety from the Line, Gilbert, and Fiji Islands.

Colour in alcohol: generally dark brown with scale centres tan to lighter brown; white blotch present on forehead and upper sides of juveniles and subadults; adults without forehead spot and frequently without blotch on back; fins blackish, except pectorals pale and outer half of soft dorsal fin frequently pale; small black spot present at base of upper pectoral rays.

RANGE: Widespread in the Indo-W. Pacific from the Red Sea and east African coast as far south as Durban to the central and western Pacific as far north as southern Japan and south to the Sydney area of Australia; the Line Islands, Tuamotu Archipelago, and Pitcairn Group form the eastern limit of distribution. It is replaced by the closely related *D. albisella* in the Hawaiian Islands and *D. strasburgi* in the Marquesas Islands.

BIOLOGY: This species inhabits lagoons, passes, and outer reef environments at depths ranging from about one to at least 55 metres. It occurs in small to relatively large (over 50 individuals) aggregations in either rocky or coraliferous areas. They spend much of the time feeding on plankton well above the bottom. Allen (1975) examined the stomach contents of several specimens from the Palau Islands and found they contained about 40% algae and 60% copepods and other planktonic crustaceans.

The reproductive behaviour of this species has been studied by Garnaud (1957), Koenig (1958) and Allen (1975). Courtship is characterised by male "signal-jumping" similar to that described above for *D. aruanus*. Eggs are laid on dead coral branches, bare rock, or even man-made substrata such as abandoned cables or shipwrecks. Garnaud reported thrice monthly spawnings in a captive pair of *D. trimaculatus* with a total of 17 over a seven-month period. The number of eggs per spawning was estimated at 20,000-25,000. The male aggressively guards the nest and cares for the eggs during the incubation period which lasts about three days at temperatures ranging between 26°-28°C, or four days at 24°C. The newly hatched fry are slightly under 2 mm total length, but are nearly double this figure after one week. They are presumed to lead a pelagic existence for the first few weeks.

The juveniles of *D. trimaculatus* are usually associated with either branching corals or relatively large sea anemones of the same type which harbour *Amphiprion* and *Premmas* (Mariscal, 1966; Schlichter, 1968 and 1969; Probst, 1969). As many as 60 individuals have been found with a single large anemone (Allen, 1972). Young *Dascyllus* generally remain further away from the anemone than *Amphiprion,* making only infrequent contacts with the tentacles. However, when pursued by a diver they plunge headlong into the tentacles and remain hidden there until the danger has passed. Adult *D. trimaculatus* usually do not associate with anemones, but nevertheless may remain in the immediate vicinity.

MATERIAL EXAMINED: We have examined more than 200 specimens, 19-110 mm, from the following localities: Red Sea, Somali, Kenya, Seychelles, Aldabra Atoll, Comoro Islands, Madagascar, St. Brandon's Shoals (Cargados Carajos), Maldive Islands, Sri Lanka, Thailand, Indonesia, Philippine Islands, Australia, Lord Howe Island, Caroline Islands, Marshall Islands, New Guinea, Solomon Islands, New Hebrides, New Caledonia, Gilbert Islands, Fiji Islands, Line Islands, Society Islands, Tuamotu Archipelago and Pitcairn Group. These localities have been reported by previous authors, most of them by either de Beaufort (1940), Smith (1960) or Allen (1975). In addition, we have examined the type specimens of *trimaculatus* (SMF 1445, 82 mm), *nuchalis* (BMNH 1861.6.4.3, 41 mm), and *unicolour* (BMNH 1855.12.26.474, 81 mm).

The junior author was unable to locate Bleeker's type of *D. niger* during a visit to RMNH in 1975. However, the original description provides enough detail to allow us to confidently place this species in the synonymy of *D. trimaculatus*. Moreover, Bleeker himself included *niger* as a junior synonym of this species in his 1877 review of the East Indian Pomacentridae.

We have not seen the type specimen of *D. axillaris,* a specimen approximately 90 mm TL which is deposited at the J. L. B. Smith Institute of Ichthyology, Grahamstown, South Africa. However, we agree with Smith, the original author of this species, who later (1960) placed it in the synonymy of *D. trimaculatus*.

Dascyllus strasburgi Klausewitz Fig. 6

Dascyllus strasburgi Klausewitz, 1960: 45 (type locality, Marquesas Islands).

DIAGNOSIS: (Proportions based on 15 specimens, 42-82 mm). Dorsal rays usually XII,14 to 15; anal rays usually II,14; pectoral rays 20 or 21; tubed lateral-line scales usually 19; gill rakers on first arch usually 6 or 7 + 15 to 17; greatest depth of body 1.6, head length 3.1 to 3.4, both in standard length; snout length 3.2 to 4.2, eye diameter 2.5 to 2.9, interorbital width 2.7 to 3.1, least depth of caudal peduncle 1.6 to 1.9, length of caudal peduncle 2.3 to 3.0, of pectoral fin 0.9 to 1.1, of pelvic fin 0.8 to 1.0, of caudal fin 0.9 to 1.1, caudal concavity 6.7 to 7.3, all in head length.

Fig. 6. *Dascyllus strasburgi,* 80 mm, Marquesas Islands (J. Randall photo).

Colour in life: coloration of a fresh specimen was illustrated by Allen (1975). The same individual appears in Fig. 6. The fresh coloration was as follows: head and anterior body dusky grey (slightly greenish), grading to a dirty bluish-white on posterior part of body; opercular membrane and lips light blue; scales of body with dark grey margin and dark grey streak across centre; white spot about size of eye above 11-12th lateral-line scales; fins bluish-white except pectorals transparent; base of pectoral fin bluish-white with small black spot at base of uppermost rays.

Colour in alcohol: head and anterior portion of body brown grading to yellowish posteriorly, lips and opercular membrane pale; scales with brownish margins more noticeable on anterior half of body; remnant of white spot barely distinguishable above 11-12th lateral-line scales; fins yellowish with very narrow dark margin on dorsal and anal; pectorals with small dark brown spot at base of uppermost rays, axil of fin pale.

RANGE: Known only from the Marquesas Islands where it apparently replaces the closely related *D. trimaculatus*.

BIOLOGY: There is no published information on the biology of this species. The behaviour and reproductive habits are probably similar to *D. trimaculatus*. J. Randall (personal communication) collected specimens from rocky areas in five to 12 metres depth during a visit to the Marquesas Islands in 1971.

REMARKS: It is difficult to assess the taxonomic status of *D. strasburgi*. The species is closely allied to *D. trimaculatus* differing primarily in colour pattern; there is also a slight modal difference in the pectoral ray count (see Table 1). It is indeed tempting to consider *strasburgi* as merely a subspecies of *trimaculatus*. However, on the basis of the geographic isolation of the Marquesan population, coupled with the significant colour pattern difference it is our opinion that full specific status is warranted. In spite of the wide distribution of *D. trimaculatus* there is virtually no geographic variation in colour pattern (variation due to ecological conditions may occur at a given locality).

MATERIAL EXAMINED: We have examined 53 specimens, 32-83 mm, including the holotype (USNM 190596, 69 mm) and two paratypes (SMF 5111-12, 57 and 82 mm); all specimens from the Marquesas Islands.

Dascyllus marginatus (Rüppell) Fig. 7

Pomacentrus marginatus Rüppell, 1828: 38 (type locality Red Sea).

DIAGNOSIS: (Proportions based on 21 specimens, 28-43 mm). Dorsal rays XII,14 or 15; anal rays usually II,13; pectoral rays usually 18 or 19; tubed lateral-line scales usually 17 or 18; gill rakers on first arch usually 7 or 8 + 20 to 23; greatest depth of body 1.4 to 1.5, head length 2.9 to 3.1, both in standard length; snout length 3.6 to 4.1, eye diameter 2.3 to 2.8, interorbital width 2.7 to 3.1, least depth of caudal peduncle 1.7 to 2.0, length of caudal peduncle 3.0 to 4.5, of pectoral fin 1.1 to 1.3, of pelvic fin 0.8 to 1.0, of caudal fin 0.9 to 1.2, caudal concavity 3.6 to 5.5, all in head length.

Colour in life (from a 35 mm Ektachrome transparency taken by the junior author at Eilat, Red Sea in 12 metres depth): ground colour of head and body white, slightly yellowish on upper half; most of body scales with bluish margin, most conspicuous on upper half of body; spinous dorsal fin white with broad black outer margin, tapering in width posteriorly and ending at tip of anterior soft rays; soft dorsal and caudal fins transparent, but slightly bluish; anal fin similar to dorsal with prominent black margin covering spinous portion and outer part of first 5 or 6 soft rays; pelvic fins mostly black, except two innermost rays white; pectoral fins transparent with large black spot covering basal portion and axil.

Fig. 7. *Dascyllus marginatus*, approximately 40 mm, Elat, Red Sea in 12 metres depth.

Colour in alcohol: similar to live coloration except ground colour yellow or tan and scale margins dusky.

RANGE: Known in the Red Sea, as far south as Melita Bay, Ethiopia (approximately 15°15'N; 39°49'E) and northward to the Gulfs of Suez and Aqaba; also recently collected by the junior author in the Gulf of Oman, north-western Indian Ocean.

BIOLOGY: Klausewitz (1958) and Fishelson *et al.* (1974) described the habitat and behaviour of *D. marginatus* in the Gulf of Aqaba. Essentially the species is found in association with the branching corals *Stylophora pistillata, S. wehlsi,* and species of *Acropora* and *Porites* in depths ranging to at least 15 metres. Groups of 10-20 individuals inhabit isolated coral heads and the social structure and general behaviour is similar to that of *D. aruanus*. Tortonese (1968) noted this species was the most common *Dascyllus* present at Eilat, Gulf of Aqaba.

REMARKS: *D. marginatus* is most closely allied to *D. carneus* from the Indian Ocean. These species represent the smallest members of the genus, rarely exceeding 50 mm SL. Although very similar in shape they differ significantly in colour pattern and counts for the pectoral rays and gill rakers (see Tables 1 and 2).

Marshall (1952) divided *D. marginatus* into two subspecies, *D. marginatus marginatus* from the Red Sea and *D. marginatus reticulatus* from the Indo-West Pacific. However, we find that the latter grouping is distinct from *marginatus* and actually consists of two species, *D. carneus* and *D. reticulatus*. Marshall suggested that specimens from the Gulf of Aden might be intermediate between *marginatus* and *reticulatus,* but according to his illustration these appear to be conspecific with Red Sea *marginatus*. However, there is a slight difference in the coloration of the dorsal and anal fins. In specimens from the Gulf of Aden the dorsal has a slightly wider black margin and the anal is entirely black except the posterior edge has a narrow pale border. Specimens from the Red Sea have a dark area on the anal fin which is restricted to the spinous portion and outer part of the anterior five or six soft rays. Colour variation of this magnitude which is correlated with geography is not uncommon in pomacentrids (see Allen, 1975).

MATERIAL EXAMINED: We have examined 103 specimens, 12-47 mm, from the Gulf of Aqaba and Melita Bay (Ethiopia). In addition, Rüppell's type, 29 mm, and six paratypes, 27-29 mm, were studied at SMF (register number 1498).

Dascyllus carneus Fischer Figs. 8 and 9

Dascyllus carneus Fischer, 1885: 71 (type locality, Mozambique).

Dascyllus nigripinnis Regan, 1908: 228 (type locality, Maldive Islands).

DIAGNOSIS: (Proportions based on 19 specimens, 30-45 mm). Dorsal rays usually XII,15; anal rays usually II,13; pectoral rays usually 20 or 21; tubed lateral-line scales usually 17 or 18; gill rakers on first arch usually 7 + 17 to 19; greatest depth of body 1.5 to 1.6, head length 3.0 to 3.4, both in standard length; snout length 3.4 to 4.0, eye diameter 2.1 to 2.4, interorbital width 2.9 to 3.4, least depth of caudal peduncle 1.7 to 2.0, length of caudal peduncle 2.5 to 3.2, of pectoral fin 1.0 to 1.2, of pelvic fin 0.8 to 1.0, of caudal fin 0.9 to 1.0, caudal concavity 2.9 to 3.9, all in head length.

Colour in life: there are two colour phases which appear to be correlated with geography. Individuals from the western Indian Ocean have the following coloration (from Burgess and Axelrod, 1973): ground colour of head and body pale yellow, most of head and breast scales with one or more small blue dots, those on forehead and nape

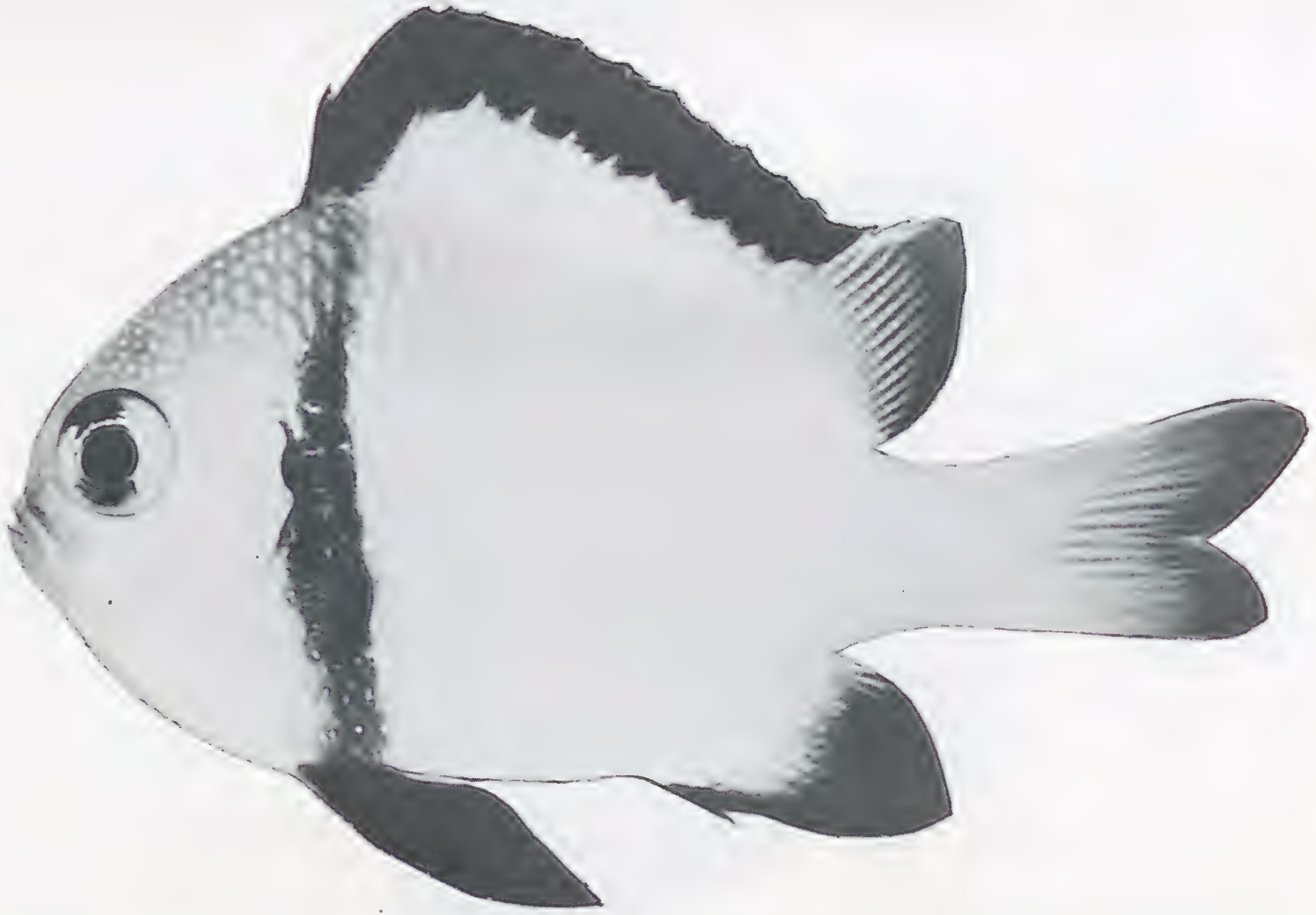

Fig. 8. *Dascyllus carneus*. 34 mm, Seribu Islands, Java Sea (Note — The outer edge of the soft dorsal and caudal fins are transparent, but the specimen was originally photgraphed on a dark background).

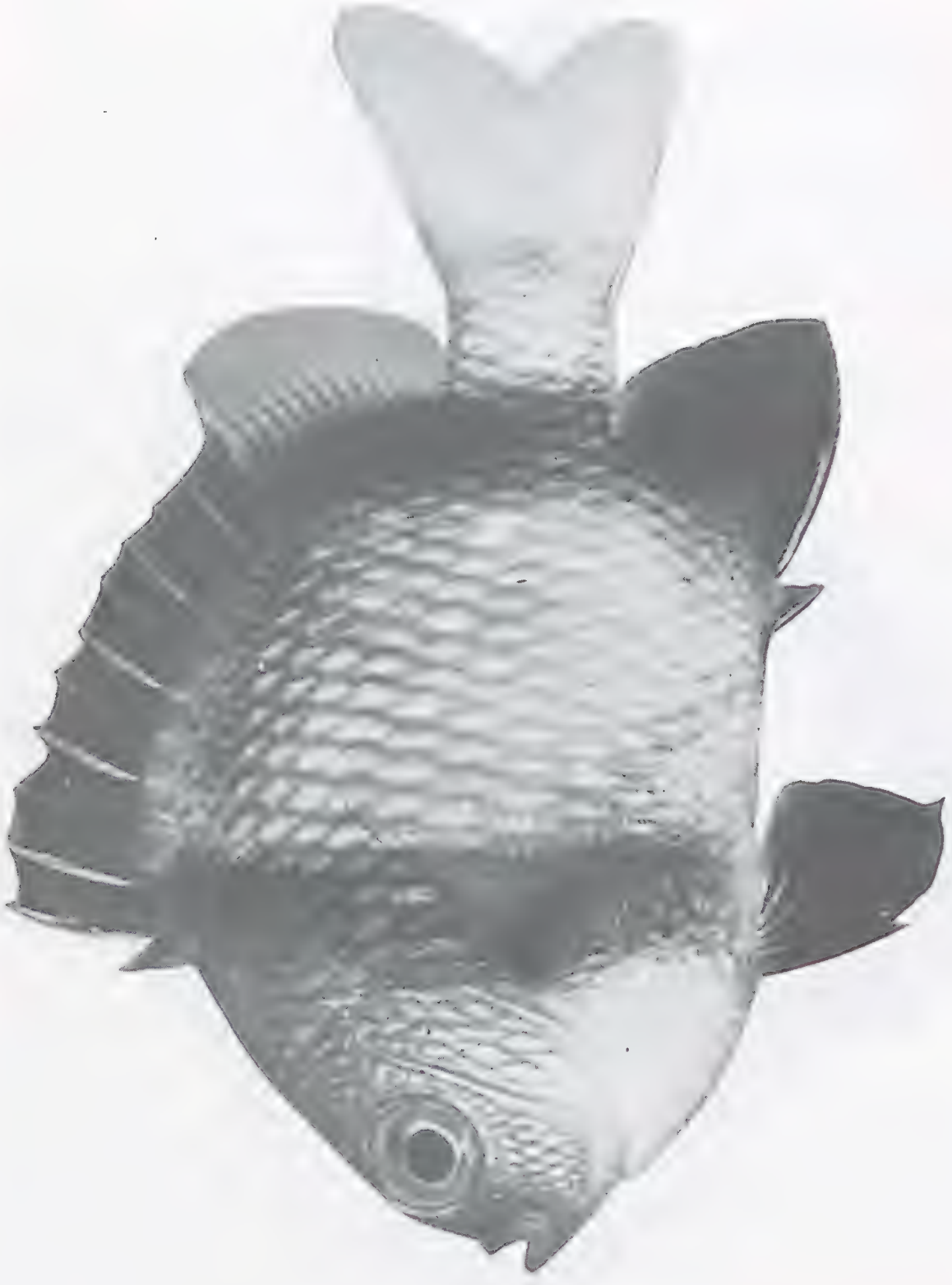

Fig. 9. *Dascyllus carneus*, 44 mm, SL Seychelles (J. Randall photo).

forming oblique rows which ascend toward dorsal fin; lips blue; basal portion of body scales slightly dusky, a blue streak across centre of scales on upper back; a pair of prominent black bars (4-5 scales wide) on body, the first from base of anterior dorsal spines to base of pelvic fins, the second covering basal (i.e., anterior) portion of soft dorsal fin and continued across posterior part of body, also covering most of anal fin; caudal peduncle and base of caudal fin white; large white spot (about three times size of eye) on upper portion of body just behind anterior black bar and below spinous dorsal fin; spinous dorsal and anal fins black with spines blue; soft dorsal fin transparent to slightly bluish except black basal portion; outer half of caudal fin transparent to slightly bluish; pelvic fins black with spine and anterior edge of fin blue.

Individuals from the Maldives, Thailand, and Seribu Islands, Java Sea are somewhat different in coloration. The pattern is described from a 35 mm Ektachrome transparency taken by the junior author in 10 metres depth at Pulau Putri, Seribu Islands: ground colour of head and body white, blue spots present on scales of head and breast; spots fainter than those of western Indian Ocean fish; a single black bar on body in same position as anterior bar in western Indian Ocean specimens; outer half of spinous dorsal fin black, basal half white; soft dorsal and caudal fins transparent to slightly bluish; anal fin mostly black except white on basal portion; pelvic fins black; pectoral fins transparent.

Colour in alcohol: similar to live coloration except ground colour yellowish to dusky grey with black bars less contrasted.

RANGE: Known from the east coast of Africa as far south as Delgoa Bay, Mozambique, and from the islands of the western Indian Ocean including Madagascar, Mauritius, St. Brandon's Shoals (Cargados Carajos), Réunion, Comoro, Seychelles, and Aldabra Atoll. In the central Indian Ocean it is known from the Chagos Archipelago, Maldives and Sri Lanka, and it also occurs off the west coast of Thailand and in the Java Sea at the Seribu Islands, off Jakarta, Java. The latter area represents the only locality outside of the Indian Ocean. This pentration has most likely occurred via the nearby Sunda Strait, the narrow passage between Java and Sumatra. Judging from existing museum collections the penetration into the Java Sea appears to be confined to the area immediately adjacent to this passage. *Amphiprion akallopisos,* another widespread Indian Ocean pomacentrid also occurs in the Seribu Islands (Allen, 1972). Both species, however, are absent from the coast of northwestern Australia, being replaced there by their W. Pacific counterparts, *Dascyllus reticulatus* and *Amphiprion sandaracinos* (Allen, 1976).

BIOLOGY: The junior author has made limited observations of this species at Pulau Putri, Seribu Islands near Jakarta, Indonesia. Groups containing approximately two to 20 individuals were usually associated with isolated colonies of vasiform *Acropora* corals at depths ranging between eight and 15 metres. The fish were confined to the relatively steep slope which descends from the edge of the reef flat to a depth of about 20 metres. The water was relatively turbid (horizontal visibility 10-15 metres) and the thick bottom sediment over much of the reef indicated this was a permanent condition. In the western Indian Ocean at Grande Comoro Island the species occurs to at least 30-35 metres. Specimens were recently collected at this depth by Dr. John E. McCosker.

D. carneus matures at a significantly smaller size than its close relative *D. reticulatus.* The junior author observed spawning of several individuals ranging in length from 25-38 mm at Pulau Putri. *D. reticulatus* does not normally engage in spawning under about 40 mm and in most cases the male is in excess of 55 mm (personal observations). During the spawning period the male (later collected) performed a series of "signal jumps" similar to the courtship "dance" described above for *D. aruanus.* This activity took place about 0.5

metre above an *Acropora* colony measuring approximately 0.5 metre in diameter. A group composed of about 10 smaller individuals (presumed females) either swam close to the coral or fed on plankton a short distance above. Periodically one of the smaller fish was attracted to the male's display with resulted in the latter escorting his mate to the edge of the coral formation where spawning took place. The female's ovipositor was clearly visible as she passed over the nest site, followed closely by the male whose vent was pressed against the coral substrate. Eggs could be seen clinging to the nest site if viewed carefully at very close range. The fish were observed for approximately 15 minutes and during this period the male engaged in spawning activities with at least two different females and possibly more at the same nest site.

Cobb (1975) reported on aquarium spawnings for a pair of *D. carneus*. He observed that spawning behaviour was apparently triggered by the swollen abdomen of the female. The male enticed the female to lay eggs after a period of much physical contact and body vibrations. The spawning sequence lasts approximately two hours with a density of about 100-140 eggs per square cm with an average nest size of 59 sq. cm. After spawning the male cares for the nest until hatching which takes place in about 48 hours at temperatures ranging between 26°-30°C. At this stage the fry are 1.4 mm total length.

Koenig (1957) described sound production in captive specimens of *D. carneus*.

REMARKS: *D. carneus* has been confused with *D. reticulatus* by Smith (1960) and several other authors. The two species are similar, apparently having evolved from the same ancestral stock. *D. marginatus* of the Red Sea is another close relative which differs primarily in colour pattern.

There are several important differences between *D. carneus* and *D. reticulatus*. Colour pattern is the most obvious, particularly the presence of blue spots on the head and nape of *carneus* and the lack of this feature in *reticulatus*. The spots usually show up clearly in preserved specimens and provide a quick means of identification. Maximum size is another feature which differs significantly. *D. carneus* is considerably smaller than *reticulatus*, males attain sexual maturity between 30-35 mm and the maximum length is about 50 mm; in *D. reticulatus* males mature between 45-55 mm and the maximum size is about 65 mm. In addition, there are modal differences in counts for the pectoral rays, lateral-line scales (upper series), and gill rakers (see Table 2). A further difference concerns the pattern of scalation on the chin anterior to the forward extension of the isthmus. In *D. carneus* this area is naked, but in *D. reticulatus* it is largely covered with scales.

We have not seen the types, but Ladiges *et al.* (1958) reported that the lectotype and two paralectotypes are deposited at the Zoologisches Museum, Hamburg. The original description of *D. carneus* is clearly diagnostic.

MATERIAL EXAMINED: We have examined 39 specimens, 17-47 mm, from the following localities: St. Brandon's Shoals (Cargados Carajos), Madagascar, Comoro Islands, Zanzibar, Mombasa, Chagos Archipelago, Maldive Islands, Thailand (Andaman Sea), and the Seribu Islands, Java Sea. This material includes the type of *D. nigripinnis* Regan, a specimen 50.4 mm, examined at BMNH (register number 1908.3.23.98). The Java Sea, Thailand and St. Brandon's Shoals represent new locality records.

Dascyllus reticulatus (Richardson) Fig. 10

Heliases reticulatus Richardson, 1846: 245 (type locality, China and Japan).

Dascyllus xanthosoma Bleeker, 1851: 247 (type locality, Banda Neira).

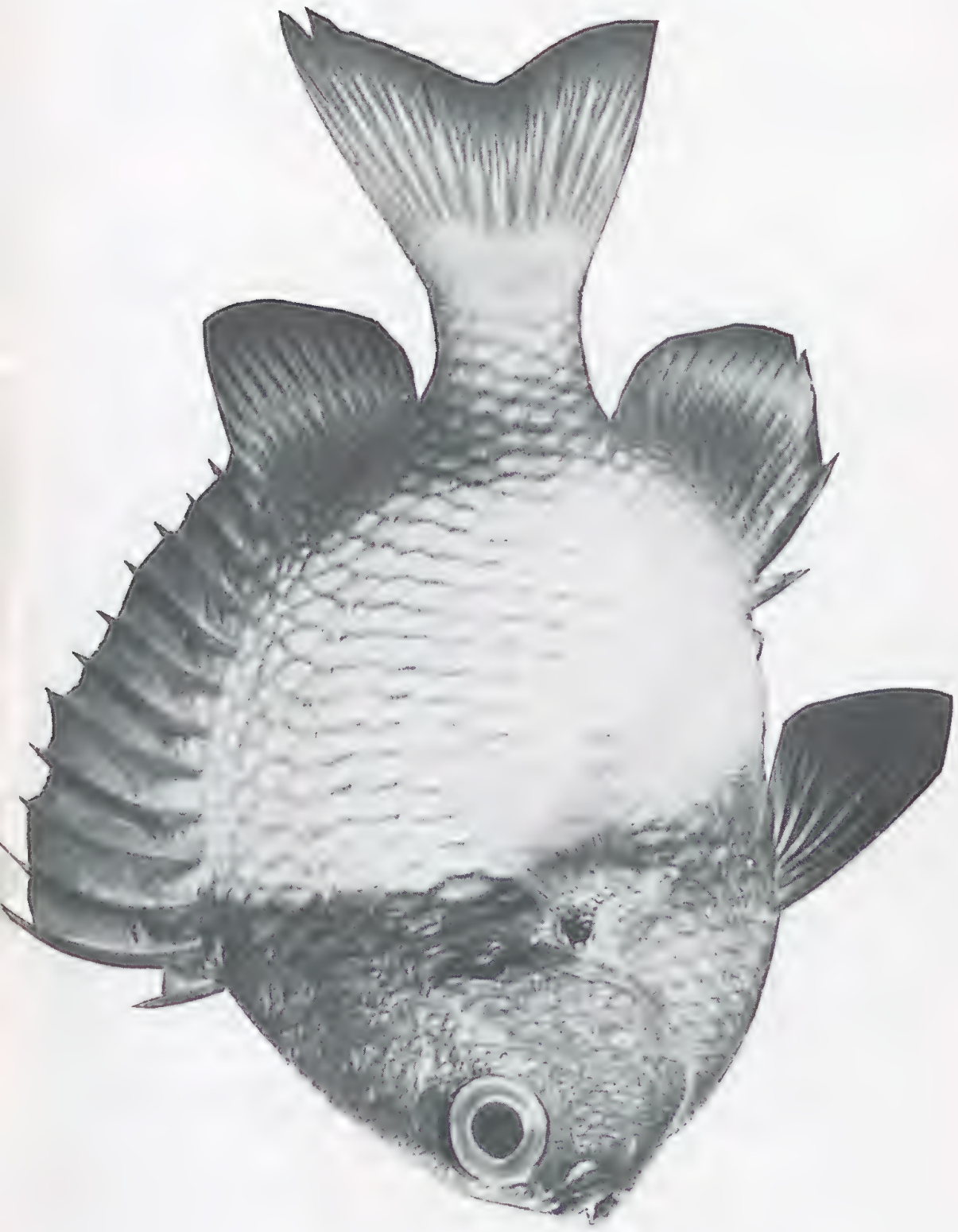

Fig. 10. *Dascyllus reticulatus*, 52 mm, Truk, Caroline Islands (J. Randall photo). (Note — The outer edge of the soft, dorsal, anal and caudal fins are transparent, but the specimen was originally photographed on a dark background).

Pomacentrus unifasciatus Kner, 1868: 348 (type locality, Fiji Islands).

DIAGNOSIS: (Proportions based on 30 specimens, 45-63 mm). Dorsal rays usually XII,15; anal rays II,13; pectoral rays usually 20; tubed lateral-line scales usually 18; gill rakers on first arch usually 7 + 19 to 21; greatest depth of body 1.4 to 1.6, head length 3.0 to 3.3, both in standard length; snout length 3.0 to 3.8, eye diameter 2.3 to 2.8, interorbital width 2.7 to 3.3, least depth of caudal peduncle 1.8 to 2.0, length of caudal peduncle 2.6 to 3.2, of pectoral fin 1.0 to 1.1, of pelvic fin 0.9 to 1.0, of caudal fin 0.9 to 1.0, caudal concavity 2.5 to 3.6, all in head length.

Colour in life: live colours are variable according to ecological conditions and behaviour. The basic pattern was illustrated by Allen (1975) and consists of a whitish ground colour with the following markings: snout, interorbital, and forehead slightly greenish; upper edge of operculum and opercular membrane dark brown; prominent black bar (2-3 scales wide) extending from base of first three dorsal spines to base of pelvic fin, becoming relatively faint below pectoral fin; a second, less distinct bar across anterior half of soft dorsal fin and continued across posterior part of body, extending on to anterior portion of anal fin; scale margins faintly brown or blackish; spinous dorsal fin same as body colour on basal half with broad black margin on outer half; soft dorsal fin transparent to slightly bluish except for black bar on anterior portion; anal fin similar to soft dorsal; caudal mostly transparent, but slightly dusky and bluish on outer edges; pelvic fins mostly black except innermost ray white; pectoral fins transparent with small black spot at base of uppermost rays. The ground colour is often overall dusky with only a faint suggestion of the dark bars.

Colour in alcohol: similar to live coloration except ground colour yellowish to dusky grey and bars far less contrasted. The hindmost bar is frequently absent and occasionally the entire specimen is overall dark grey (except for darker scale margins) without bars.

RANGE: Known from Cocos-Keeling Atoll and Western Australia in the eastern Indian Ocean, the Gulf of Thailand, South China Sea, Indonesia, Philippines, Taiwan, Ryukyu Islands, southern Japan, east coast of Australia, Melanesia, Micronesia, and the islands of Polynesia excluding the Hawaiian Islands and those in the south-eastern portion lying to the east of and including the Society Islands.

BIOLOGY: This species inhabits lagoons, the edge of passes leading to the open sea, and outer reef slopes, usually in one to at least 50 metres. Observations by the junior author at the Marshall Islands, Palau, and off Western Australia indicate the general habits and behaviour are very similar to those described for *D. aruanus*. The spawning behaviour was reported by Wickler (1967) and is typical for the genus.

REMARKS: De Beaufort (1940) incorrectly used the name *D. marginatus* (non Rüppell) for this species. His locality records from the Red Sea and western Indian Ocean refer to *D. marginatus* and *D. carneus* respectively.

MATERIAL EXAMINED: We have examined 179 specimens, 9-63 mm, from the following localities: Cocos-Keeling Atoll, Western Australia, Vietnam, Indonesia, Borneo, Philippine Islands, Palau Islands, New Guinea, Trobriand Islands, New Georgia, Solomon Islands, New Hebrides, Fiji Islands, and the Marshall Islands. All of these localities except Cocos-Keeling were reported previously by either De Beaufort (1940) or Allen (1975 & 1976). The material includes the probable type of *D. xanthosoma* Bleeker, a specimen 41 mm, examined at RMNH (register number 6455).

According to Günther (1862) "the typical specimens [of *Heliases reticulatus*] appear to be lost." However, the characters given by Richardson (1846) in his brief description are diagnostic.

We have not examined the type of *Pomacentrus unifasciatus* which was described by Kner (1868) on the basis of a single Fijian specimen in the Godeffroy Museum, Hamburg (number 3788). However, the original description is very complete and the accompanying figure is clearly diagnostic. On the basis of these items we have placed this species in the synonymy of *D. reticulatus*.

Dascyllus flavicaudus n.sp. Fig. 11

Dascyllus sp. one Harry, 1953: 104 (Raroia Atoll, Tuamotu Islands).

Dascyllus sp. Axelrod, Burgess, and Emmens, 1975: 340.00 (Tahiti).

HOLOTYPE: BPBM 13031, 87.0 mm, collected with spear on reef of Haurei Bay, Rapa (approximately 27°45'S, 144°30'W) in 28 metres by J. Randall on 17th February, 1971.

PARATYPES: AMS I.19109-001, 2 specimens, 53.5 and 64.1 mm, collected with rotenone off small boat passage at Oeno, Pitcairn Group (approximately 23°45'S, 130°45'W) in 20 metres by J. Randall and crew of "Westward" on 18th December, 1970; BPBM 6886, 2 specimens, 78.7 and 80.0 mm, collected with rotenone at Popote Bay, Papara, Tahiti in 5 metres by J. Randall and A. Banner on 22nd February, 1969; BPBM 7192, 4 specimens, 67.1-75.5 mm, collected with rotenone at Popote Bay, Tahiti in 6 metres by J. Randall on 25th February, 1969; BPBM 13102, 5 specimens, 52.0-78.0 mm, collected with rotenone off concrete quay in pass at Takaroa, Tuamotu Islands in 10-15 metres by J. Randall and R. McNair on 13th April, 1971; BPBM 16568, 6 specimens, 52.2-77.0 mm, same collecting data as AMS paratypes; BPBM 16646, 5 specimens, 48.7-56.4 mm, collected with quinaldine at Bounty Bay, Pitcairn Island in 22 metres by J. Randall on 25th December, 1970; BPBM 16926, 66.1 mm, collected with rotenone off "The Rope", Pitcairn Island in 33 metres by J. Randall, D. Cannoy, and S. Christian on 23 December 1970; CAS 38525, 2 specimens, 67.0 and 79.0 mm, collected with rotenone on shore reef near Garumaoa village, west side of Raroia Atoll, Tuamotu Archipelago by R. R. Harry and Raroians on 18th July, 1952; CAS 38526, 66.0 mm, collected with spear off King Pomare's tomb, 2-3 miles east of Papeete, Tahiti by J. Randall on 22nd July, 1956; CAS 38527, 2 specimens, 71.0 and 73.0 mm, collected with spear just east of large wharf off village of Faatoai, Moorea by J. Randall on 27th March, 1957; CAS 38528, 3 specimens, 23.0-39.0 mm, collected with rotenone inside Teputo Pass, Papeari District, Tahiti by Ellsworth and Josef on 4th July, 1957; CAS 38529, 75.0 mm, collected with rotenone at Teauaraa Pass, Atimaono, Papara District, Tahiti by Bingham and Josef on 18th July, 1957; CAS 38530, 70.0 mm, collected with rotenone in Tareu Pass, Papetoai District, Morea by Bingham *et al*,on 27th July 1957; CAS 38531, 23 specimens, 46.0-75.0 mm, collected with rotenone in Iriru Pass, off Iriru Island, Raiatea by Bingham *et al*, on 4th August, 1957; CAS 38532, 34.0 mm, collected with rotenone north of Raititi Point, Nunug District, Bora Bora by Bingham *et al*, on 12th August, 1957; CAS 38533, 5 specimens, 29.0-76.0 mm, collected with rotenone inside edge of Muller Reef, Teavanui Pass, north of Motu Tapu, Bora Bora by Bingham *et al*, on 15th August, 1957; MNHN 1976-101, 2 specimens, 66.0 and 71.8 mm, same collecting data as AMS paratypes; USNM 216381, 3 specimens, 55.6-72.0 mm, same collecting data as BPBM 13102; WAM P25578-001, 2 specimens, 62.5 and 75.5 mm, collected with rotenone 400 m east of Teavaraa Pass, Tahiti in 30-35 metres by G. Allen, J. Randall, and B. Baker on 26th February, 1969.

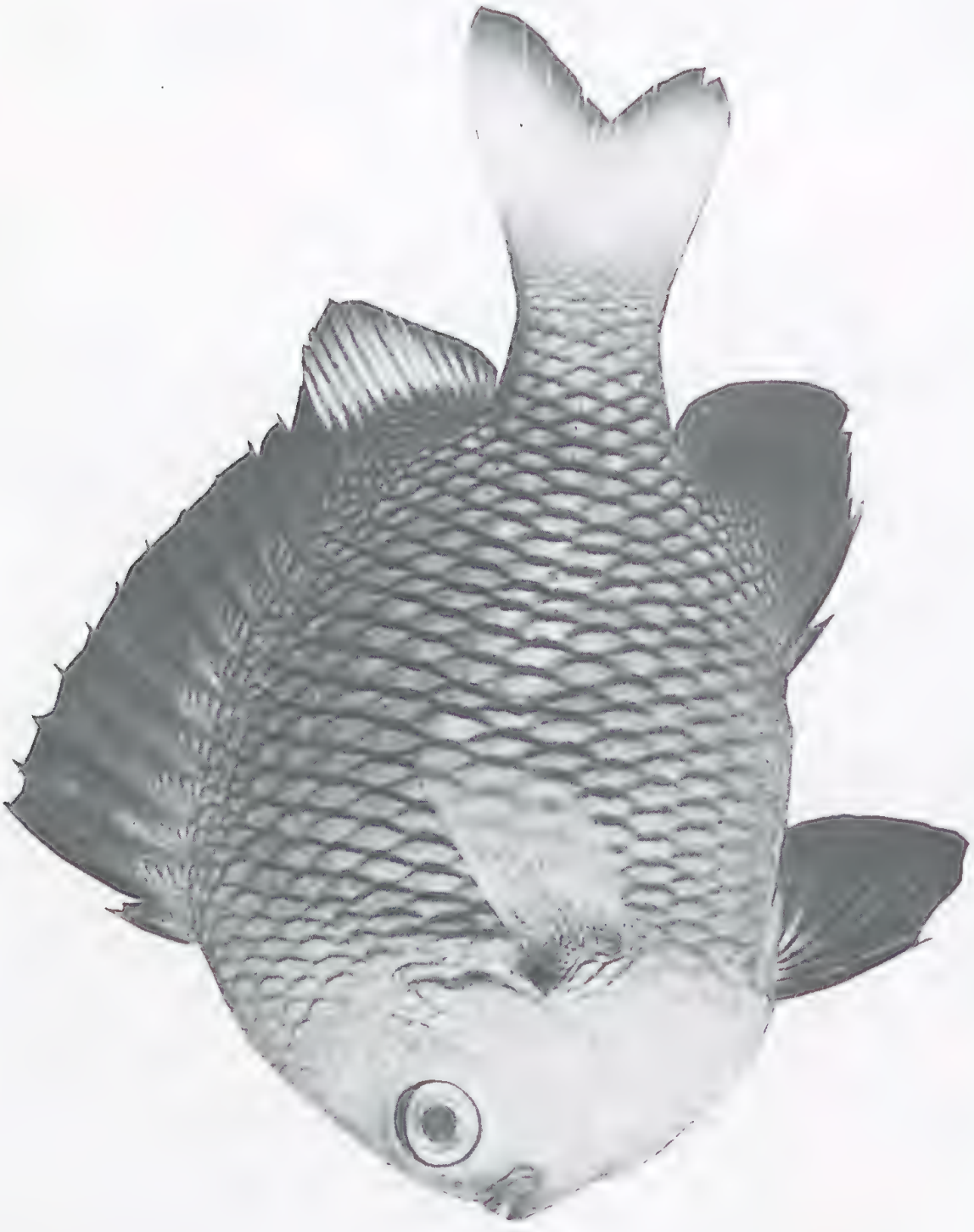

Fig. 11. *Dascyllus flavicaudus*, paratype (BPBM 7192), 75.5 mm, Tahiti (J. Randall photo). (Note — The outer edge of the soft dorsal and caudal fins are transparent, but the specimen was originally photographed on a dark background).

DESCRIPTION: The proportional measurements for the holotype and several paratypes are expressed as percentage of the standard length in Table 3. Proportions given below are based on 25 specimens, 49-87 mm.

Dorsal rays XII,15 (XII,15 or 16); anal rays II,14 (II,13 or 14); pectoral rays 20 (20 or 21); branched caudal rays 13; gill rakers on first branchial arch 7 + 20 (6 or 7 + 19 to 21); branchiostegal rays 6; lateral-line scales with tubes 18 (17 to 19); vertical scale rows from upper end of gill opening to caudal base 27 (27 to 28); horizontal scale rows from lateral-line to base of middle dorsal spines 1½; scale rows below lateral-line to origin of anal fin 10; circumpeduncular scales 15 (14 to 15).

Body relatively deep for the family, the depth 1.4 (1.4 to 1.6) in standard length, and compressed, the width about 10 times in depth; head length contained 3.3 (3.2 to 3.4) in standard length; snout 3.0 (3.1 to 3.5) in head; eye 3.1 (2.4 to 3.1) in head; interorbital space moderately convex, the bony width 3.0 (2.4 to 3.1) in head; least depth of caudal peduncle 1.8 (1.6 to 1.8) in head; length of caudal peduncle 2.3 (2.3 to 2.8) in head.

Mouth oblique, terminally located, the maxillary reaching nearly to a vertical through front edge of eye; teeth of jaws conical, multi-serial at front of jaws; upper jaw with 38 (36 to 42) teeth in outer row, the largest at front of jaw and about equal to length of anterior nostril in height; lower jaw with 30 (38 to 44) teeth, the largest placed anteriorly and similar in size to upper jaw teeth; band of close-set villiform teeth behind large conical ones at front of jaws; double nasal opening on each side of snout; anterior and posterior nostrils joined by shallow naked groove and separated by a distance slightly greater than ½ pupil width; nostrils with a low fleshy rim particularly evident around anterior one; margin of preorbital and suborbital finely serrate; combines suborbital-preorbital moderate in width, the greatest depth slightly greater than ½ eye diameter, the lower margin free; margin of preopercle finely serrate; posterior margin of opercle finely serrate to crenulate.

Scales finely ctenoid; lips naked; remainder of head and body scaled; suborbital with a single row of large scales and 1-2 rows of small axillary scales; 5 parallel rows of scales below this to lower margin of preopercle; dorsal and anal fins with a basal scaly sheath; caudal fin scaled nearly 3/4 distance to end of lobes; paired fins scaled only basally; axillary scale of pelvic fins about ½ length of pelvic spine.

Tubes of lateral-line ending below anterior rays of soft portion of dorsal fin; 2 (1 to 3) pored scales posterior to tubed scales; a series of 7 (6 to 9) pored scales mid-laterally on caudal peduncle to caudal base.

Origin of dorsal fin at level of 3rd tubed scale of lateral-line; spines of dorsal fin gradually increasing in length to 3rd or 4th spine, remaining spines gradually decreasing in length; membrane between spines scarcely incised; first dorsal spine 2.6 (2.5 to 3.2), third dorsal spine 1.2 (1.1 to 1.3), last dorsal spine 1.8 (1.9 to 2.3), longest (5th-6th) soft dorsal ray 1.4 (1.4 to 1.6), all in head; length of base of dorsal fin 1.5 (1.4 to 1.5) in standard length; first anal spine about ½ length of second anal spine or 3.3 (3.1 to 4.1) in head; second anal spine 1.6 (1.5 to 1.7), longest (5th-6th) soft anal ray 1.4 (1.3 to 1.5) in head; base of anal fin 2.4 (2.2 to 2.9) in base of dorsal fin; caudal fin emarginate, the upper lobe slightly longer than lower one, its length 1.0 (0.9 to 1.0) in standard length; caudal concavity 3.6 (2.7 to 4.0) in head length; pectoral fin relatively short, not reaching a vertical through anal opening in adults, the longest ray (uppermost branched one) 1.0 (0.9 to 1.1) in head length; pelvic fins of adults generally not reaching origin of anal fin, the longest ray (2nd from spine) 1.0 (0.9 to 1.0) in head length.

Colour in life: a colour illustration of *D. flavicaudus* by J. Randall was provided by Axelrod *et al*, (1975). The pattern consisted of the following combination: head and

breast medium brown to dark brown; lips dark grey; upper edge of operculum and opercular membrane black; scales of body, and dorsal and anal fin sheaths bluish basally with broad dark grey to blackish margins; faint dark bar extending from base of first few dorsal spines to pelvic fin base; spinous dorsal, basal 1/3 of soft dorsal, anal, and pelvic fins blackish; base of spinous dorsal with slight yellowish suffusion; outer 2/3 of soft dorsal fin pale yellow grading to transparent distally; caudal fin dusky on basal portion, remainder yellow with broad transparent border posteriorly; pectorals transparent, slightly yellowish basally with prominent black spot at base of upper rays.

Colour in alcohol: head and breast tan to light brown; lips dusky; upper edge of operculum and opercular membrane dark brown; scales of body and dorsal and anal fin sheaths light brown to reddish-brown with dusky margins; spinous dorsal, basal 1/3 of soft dorsal, anal, and pelvic fins dark brown to blackish; outer 2/3 of soft dorsal fin mainly transparent; caudal fin dusky on basal portion, remainder pale (slightly yellow) with transparent posterior margin; pectorals transparent with black spot at base of upper rays extending on to upper portion of axil, base of pectoral generally dusky.

The paratypes are generally similar to the holotype, but several are notably darker possibly due to the effects of preservation.

RANGE: Known only from the southeastern corner of Oceania including the Society Islands, Tuamotu Islands, Pitcairn Group, and Rapa.

BIOLOGY: Only sparse data are available for this species. The habitat and general behaviour appear to be nearly identical with that of *D. reticulatus*. It forms small aggregations around isolated coral heads (frequently *Pocillopora*) at depths ranging from five to at least 33 metres in passages and outer reef areas.

REMARKS: The records of *D. reticulatus* from Tahiti, Tuamotus, Rapa, and Pitcairn Group reported by Allen (1975) actually refer to *D. flavicaudus*. The species is very similar to *D. reticulatus* and probably has evolved from the same ancestral stock. However, there are important differences between them. As far as counts are concerned the most significant criteria for separation are to be found in the number of soft dorsal and anal rays and the tubed lateral-line scales (Table 1). *D. flavicaudus* usually has 14 soft anal rays or one more than the normal complement for *D. reticulatus*. The remaining count differences are modal: both species usually possess 15 soft dorsal rays; however, 33% of the *D. flavicaudus* specimens have 16 rays and none show 14 rays compared with 4% with 16 rays and 26% with 14 for *D. reticulatus*: there is a near even distribution between 18 and 19 tubed lateral-line scales for *D. flavicaudus*, whereas in *D. reticulatus* 16% of 104 specimens contained 17 tubed scales, 78% had 18, and the remaining few possessed 19.

Another, although relatively subtle difference concerns the posterior margin of the opercle below the flattened spine at the angle. In *D. flavicaudus* the margin is narrowly naked without any scales making contact with the opercular edge; however, in *D. reticulatus* at least a few scales reach to the edge of the gill flap.

There is also an apparent difference in maximum size. *D. flavicaudus* grows to at least 90 mm SL compared with about 65 mm for *D. reticulatus*. Conceivably the former species could be confused with *D. trimaculatus*, at least in the preserved state, owing to their overlapping distributions, similar size, and dark colour patterns. A good character for immediate separation is the presence of tubed scales mid-laterally on the caudal peduncle of *trimaculatus* and the lack of this feature in *flavicaudus* which only has pores or pits present.

Colour pattern differences constitute the final basis for separation between *D. flavicaudus* and *D. reticulatus*. The latter species lacks the yellow caudal fin, has the posterior portion of the anal fin pale instead of black, and has a ground colour which is largely white rather than brownish. In addition, there is only a faint hint of a dark bar below the first few dorsal spines in fresh specimens of *D. flavicaudus;* in *D. reticulatus* there are usually one or two relatively prominent bars on the body. Finally, the dark margins on the body scales are much wider in *D. flavicaudus* (compare Figs. 10 and 11).

This species is named *flavicaudus* (Latin: "yellow tail") with reference to the characteristic coloration of the caudal fin.

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Table 1. Fin Ray and Tubed Lateral-Line Scale Counts for Species of Dascyllus

Species	Soft dorsal rays						Soft anal rays					Pectoral rays					Tubed lateral-line scales					
	11	12	13	14	15	16	11	12	13	14	15	17	18	19	20	21	15	16	17	18	19	20
albisella				1	7	15				7	16			1	21	1				4	16	3
aruanus	4	223	13				2	218	20			29	197	14			1	6	138	93	2	
carneus				7	31	1			36	3				1	17	21			13	21	5	
flavicaudus					27	25			6	46					30	22			2	30	20	
marginatus				37	66				93	10			5	51	47		1	15	45	40	2	
melanurus		39	16					12	43				8	47			2	19	30	3	1	
reticulatus				27	73	4		1	93	10					5	82	17		18	81	5	
strasburgi				9	40	3			6	45	1				1	36	15			12	40	
trimaculatus				5	95	10				104	6				18	88	4		1	34	75	

Table 2. Gill Raker Counts for Species of Dascyllus

Species	5	6	7	8	+	15	16	17	18	19	20	21	22	23
albisella		8	15				4	12	7					
aruanus	2	160	76	2		3	99	113	22	3				
carneus		3	35	1				7	22	9	1			
flavicaudus			46	6						18	24	9	1	
marginatus			42	61						3	12	19	55	14
melanurus		13	41	1			1	8	36	10				
reticulatus		3	68	33					8	26	43	21	6	
strasburgi		12	38	2			7	37	5	3				
trimaculatus		58	51	1			5	47	56	2				

Table 3. Morphometric Proportions of Selected Type Specimens of Dascyllus Flavicaudus

(expressed in percentage of the standard length)

	Holotype				Paratypes			
	BPBM	BPBM	BPBM	BPBM	BPBM	WAM	BPBM	BPBM
Character	13031	16646	16646	16926	7192	P25578-001	16568	13102
Standard length (mm)	87.0	48.7	56.0	66.1	67.1	75.5	77.0	78.0
Body depth	72.2	72.3	70.5	67.6	72.0	66.2	64.0	66.7
Head length	30.1	30.4	31.8	30.3	29.8	29.4	30.1	31.7
Snout length	9.8	8.6	9.5	9.8	9.2	7.7	9.1	9.0
Eye diameter	9.8	12.7	11.3	11.6	11.9	11.3	10.9	11.5
Interorbital width	10.0	11.3	13.2	11.2	10.6	9.9	10.5	10.1
Caudal peduncle depth	16.9	16.8	17.9	17.1	18.3	17.3	16.9	17.6
Caudal peduncle width	12.9	10.7	11.6	13.0	12.2	10.7	11.2	12.8
Predorsal length	48.3	49.3	48.8	46.9	49.5	45.7	46.2	47.9
Preanal length	74.0	70.8	73.2	69.7	69.6	68.9	66.2	63.7
Prepelvic length	42.3	41.7	43.6	42.2	42.8	39.2	39.9	38.8
Dorsal base length	67.5	65.5	66.4	65.8	70.0	65.3	65.8	65.8
Anal base length	27.9	22.6	26.8	27.2	28.5	29.1	26.0	26.3
Pectoral fin length	31.6	29.2	31.8	22.8	29.8	30.5	30.1	29.7
Pelvic fin length	31.6	35.5	34.8	34.5	32.8	30.5	31.2	31.5
Pelvic spine length	23.0	25.1	25.5	24.2	21.8	23.2	23.0	21.8
1st dorsal spine	11.5	11.7	11.6	12.3	10.4	9.5	12.2	10.4
3rd dorsal spine	24.5	23.8	29.3	24.1	25.0	26.5	23.4	24.1
Last dorsal spine	16.3	15.0	16.3	14.2	15.4	15.9	13.8	13.6
5th soft dorsal ray	22.3	21.6	24.1	18.9	21.6	21.2	21.0	20.3
1st anal spine	9.2	9.7	7.7	9.7	9.6	11.1	9.5	9.6
2nd anal spine	18.6	17.5	20.4	19.7	18.3	19.2	18.2	18.2
5th soft anal ray	21.8	20.5	22.0	21.2	22.4	21.2	19.7	20.5
Caudal fin length	29.1	30.8	31.4	34.2	32.5	31.1	30.5	32.1
Caudal concavity	8.4	10.0	7.5	10.6	10.9	11.3	10.8	11.9

GUIDE TO AUTHORS

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RECORDS OF THE AUSTRALIAN MUSEUM

NATIONAL MUSEUM
10 JUL 1978
OF VICTORIA

A NEW SPECIES OF LIZARD *(LACERTILIA)*

P. R. RANKIN

TYPE SPECIMENS OF DIPTERA IN THE AUSTRALIAN MUSEUM

G. DANIELS

REPRODUCTIVE STRUCTURES OF THE GLOSSOPTERIDALES IN THE AUSTRALIAN MUSEUM

M. E. WHITE

VOLUME 31 NUMBERS 10-12 JUNE 1978 $4.00

A NEW SPECIES OF LIZARD (LACERTILIA: SCINCIDAE) FROM THE NORTHERN TERRITORY, CLOSELY ALLIED TO *CTENOTUS DECANEURUS* STORR.

NATIONAL MUSEUM
10 JUL 1978
OF VICTORIA

P. R. RANKIN

12 Finlays Avenue, Earlwood, N.S.W.

SUMMARY

A new species of *Ctenotus* is described. It is ecologically and morphologically distinct from *C. decaneurus,* its nearest congener. Current data suggest that it is restricted to coastal alluvial plains whereas *C. decaneurus* inhabits stony hill country.

INTRODUCTION

The genus *Ctenotus* (Storr, 1964) is large and widespread throughout continental Australia. Of the forty-six currently recognised species in the genus, twenty-nine have been described in recent years by Dr. Glen Storr in reviews of the genus in the western half of the continent (Storr 1969, 1970, 1971, 1974, 1975). Although the genus is already large, one can anticipate further additions, especially in eastern Australia.

The species described below was collected by the author in the Northern Territory in 1975. Initially two apparently distinct species of *Ctenotus,* readily separable under field conditions, both keyed out on morphological criteria to *Ctenotus decaneurus* (Storr, 1970). Further study revealed that *C. decaneurus* was described from material encompassing the two taxa, and that both have until now, been regarded as a single species.

The new member of this species-pair is described below, together with some limited information on its distribution and habitat preferences. In view of the fact that the status of *Ctenotus decaneurus* (*sensu* Storr 1970, 1975) is now changed, this latter species is re-defined and information provided on its habitat and distribution.

The new species is named in honour of Dr. Glen Storr in recognition of his contribution to our understanding of the taxonomy of the genus *Ctenotus*.

Ctenotus storri sp. nov.
Figs 1, 2, 3, 7

Ctenotus decaneurus (part) Storr, 1970, J. Proc. R. Soc. West. Aust., 52 (4): 104.

Ctenotus decaneurus (part) Storr, 1975, Rec. West. Aust. Mus., 3 (3): 234.

HOLOTYPE: R745 (formerly NTR 303), an adult female in the Australian National Wildlife Collection, C.S.I.R.O. Division of Wildlife Research, Canberra, A.C.T. Collected by J. Wombey, 23rd July, 1972 at Tapa Bay, Cox Peninsula, Northern Territory in Lat: 12°27′S, Long: 130°37′E.

Records of The Australian Museum, 1978, **Vol. 31, No. 10,** 395-409, Figures 1-7

PARATYPES: Australian National Wildlife Collection, Canberra, A.C.T. R746 (formerly NTR 233), R773 (formerly NTR 197), R774 (formerly NTR 227), R775 (formerly NTR 205) Berrimah, Darwin, Northern Territory in Lat: 12°25'S, Long: 130°55'E. Australian Museum, Sydney, N.S.W.: R51993, Adelaide River Township, Northern Territory in Lat: 13°05'S, Long: 131°06'E.

DIAGNOSIS: *Ctenotus storri* is a small member of the *taeniolatus* group of Storr[1], with a total of eight indistinct pale longitudinal body stripes, and no pale spots or flecks in the dorsal and lateral colour pattern. Distinguished from other members of the *taeniolatus* group by a broadly enlarged uppermost ear lobule. Further distinguished from *C. impar, C. dux, C. ariadnae,* and all subspecies of *C. quattuordecimlineatus* by fewer pale longitudinal body stripes. Separable from *C. decaneurus* generally by fewer pale body stripes, although *C. decaneurus* occasionally has only eight when the pale ventro-lateral is absent. Further diagnosed from *decaneurus* by having the pale paravertebral stripes coalescing for at least part of their length. Distinguished from *C. piankai* by the presence of a lighter stripe between the paravertebrals and dorso-lateral stripes, and from *C. taeniolatus* by the absence of a distinct broad black vertebral stripe extending for the full length of the body.

DESCRIPTION OF HOLOTYPE: SVL: 40.5 mm; Length of tail (original): 78 mm (192% of SVL); Length of forelimb: 10 mm (25% of SVL); Length of hindlimb: 18.5 mm (46% of SVL); Axilla-groin length: 21 mm (52% of SVL); Snout to anterior insertion of forelimb length: 13 mm (32% of SVL); Nasals in moderate contact; Prefrontals widely separated, Supraoculars 4/4, 3/3 in contact with frontal. Supraciliaries seven on left hand side, six on right hand side. Second loreal 1.1 times as wide as high. Supralabials 7/7. Ear lobules 3/3, all obtuse, uppermost on both sides broadly enlarged. Nuchals in four pairs. Midbody scale rows 25. Lamellae under fourth toe 21, each with a relatively narrow brown callus. Toe nails long and sabre-like (see Fig. 1).

Colour and pattern (in alcohol): Head and base colour of dorsum light brown. A total of eight pale dorsal and lateral stripes. An indistinct narrow, dark brown vertebral stripe beginning on nape, almost indiscernible at level of hindlimbs. Paravertebrals pale brown, wide, joining at about level of hindlimbs (when viewed from behind) and extending full length of tail. A pale brown longitudinal stripe between paravertebral and dorso-lateral stripes, beginning on parietals, terminating at base of tail, and separated from paravertebral by a dark brown intermediate zone. A narrow, pale brown dorso-lateral stripe beginning on outer edge of supraoculars and extending well on to tail, separated from dorsal stripes by a moderately wide dark brown to black stripe beginning on supraoculars and extending for about half length of tail. Upper lateral zone black, beginning on lores and extending for almost full length of tail. A distinct white unbroken temporal streak beginning posterior to eye and terminating anterior to ear aperture. A well defined white midlateral stripe, beginning on supralabials, looping over ear aperture and extending to hindlimb, uninterrupted by forelimb, and bordered below by a dark brown stripe beginning at ventral edge of ear aperture and extending to hindlimb. No ventro-lateral stripe. Ventral surface whitish. Limbs light brown striped longitudinally with dark brown.

VARIATION IN THE FIVE PARATYPES: Meristics and measurements are included in Table 1. In all specimens nasals in short to moderate contact and prefrontals widely separated. Supraoculars 4/4, 3/3 contacting the frontal in all cases except for ANWC R775 in which there are five on right hand side with four contacting the frontal. Uppermost ear lobule always broadly enlarged. Lamellae under fourth toe all with relatively narrow brown calli, toe nails long and sabre-like.

1. The *taeniolatus* group has never been formally defined (Storr, 1969, p. 98), nor has a list of the species contained in the group been published.

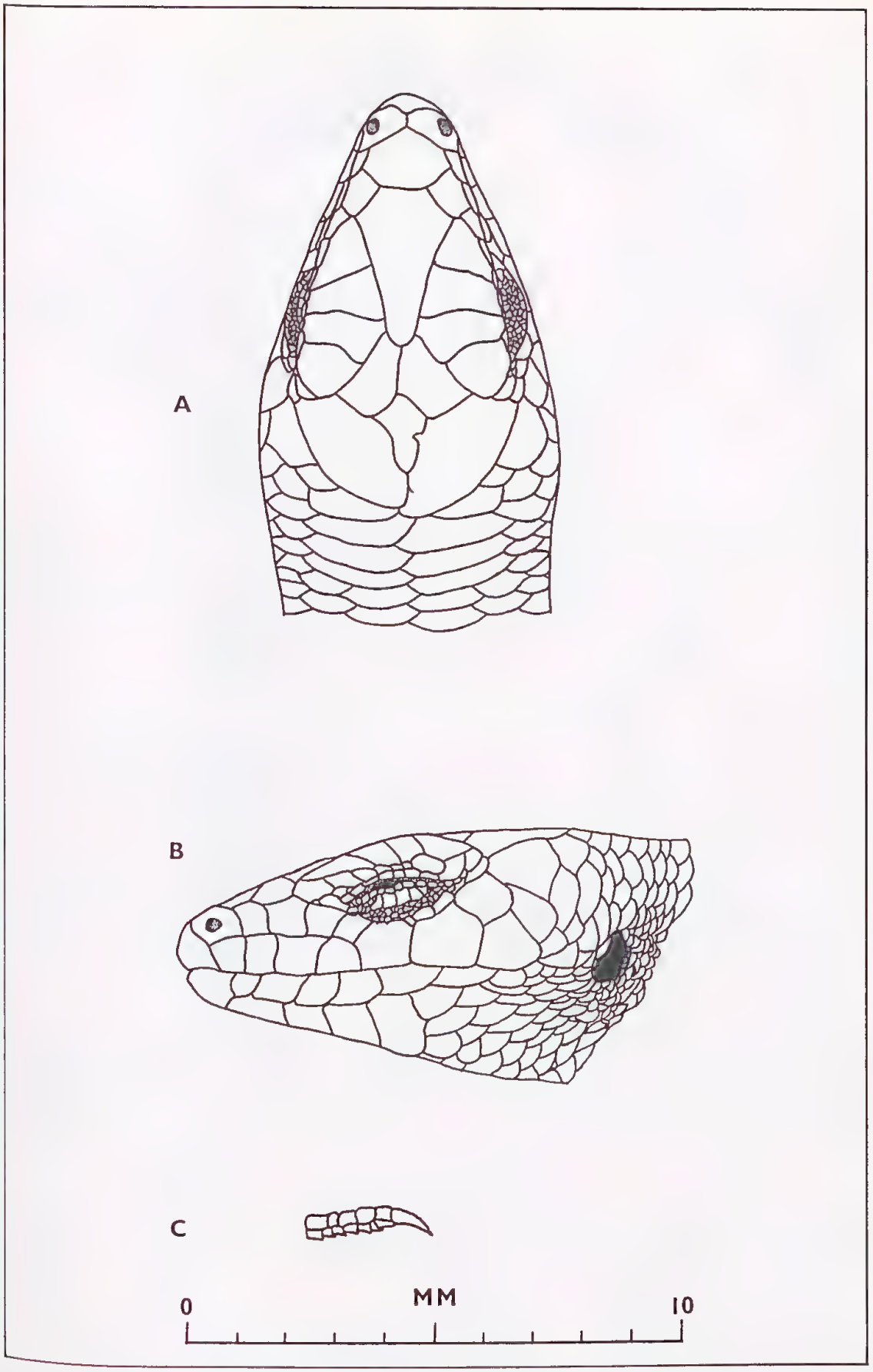

Fig. 1. Holotype of *Ctenotus storri* (ANWC R745). A. Dorsal aspect of head. B. Left lateral aspect of head. C. Lateral aspect of tip of fourth toe on left hind limb.

Colour and pattern (in alcohol): Generally similar to holotype, except that all specimens have more dark brown or black colouring on their heads. The juveniles have a tendency to have a more distinct dark vertebral stripe, and all of the series but ANWC R775 have broken but nevertheless distinct white temporal streaks. All are immaculate white ventrally.

OTHER SPECIMENS EXAMINED: A further two specimens in the Australian Museum collection were examined but their condition was too poor to qualify them for inclusion in the type series. These were R13005, from Darwin area, N.T., collected by V. R. Laird in 1944; and R56947 from Koongarra Mining Camp, Mt. Brockman Ra., N.T. in Lat: 12°53'S, Long: 132°50'E, collected by H. G. Cogger, February-March, 1973. No measurements or meristics were taken on the latter specimen, but those obtainable from R13005 are included in Table 1. The colour and pattern of both specimens is mainly bleached out, but clearly conforms to that of the type series.[2]

DISTRIBUTION: Probably restricted to plains associated with the coastal and near coastal regions of the north-western portion of the Northern Territory.

HABITAT AND ECOLOGY: The specimen AM R51993 was among five *C. storri* observed by the author at Adelaide River. Unfortunately, due to difficult collecting conditions, it was the only one secured. All were observed during the late mornings of the 15th-16th September, 1975 on the sandy alluvial plain between Mt. Carr and Adelaide River. Although the site was examined at varying times during the several visits to the area, *C. storri* was observed only during the one visit specified. At the time of this visit the area consisted of a secondary vegetation regrowth resulting from the original plant community having been cleared fairly recently. There were extensive areas of bare soil between the small clumps of young trees. All of the skinks were seen running actively across open spaces between the shade of trees, and those which escaped did so by diving down burrows in the soil. These burrows were presumably dug by the skinks themselves as they were of approximately the diameter of their bodies, and when pursued the lizards obviously knew where the burrows were. The narrow diameter of the burrows, as well as the fact that they plunged very steeply into the ground meant that effective excavation was almost impossible. It is of interest that the burrows were generally found in small pits in the ground such as hoof marks. Possibly such sites afford concealment of the burrow entrance, and/or permit the lizard to use a vertical surface into which it can dig easily. While being pursued the lizards did not run immediately to their burrows, but attempted to hide under clumps of grass and leaves before using the burrow.

Mr. J. Wombey kindly provided the author with the data sheets for the ANWC specimens, and the following information was obtained. All were taken in open coastal forest, and the data on the Tapa Bay specimen indicate that the soil type was sandy (the author has observed that the soil type around Berrimah is of a similar nature). All were active at the time of capture, and the actual times and dates of capture were: 1015 hrs, 26th October, 1971; 1030 hrs, 23rd July, 1972; 1040 hrs, 20th November, 1971; 1140 hrs, 2nd February, 1972; 1430 hrs, 20th February, 1972. These times compare closely with those observed by the author at Adelaide River. The specimen from Koongarra was collected in a flat sandy area of tropical woodland adjacent to the massive outcrops of Kombalgie sandstones in the Mt. Brockman region of the western escarpment of Arnhem Land (H. Cogger, pers. comm.).

It would seem probable on the basis of the above data that *C. storri* is associated with coastal woodland on sandy soils, and that it relies on burrowing as a form of protective cover.

2. See addendum.

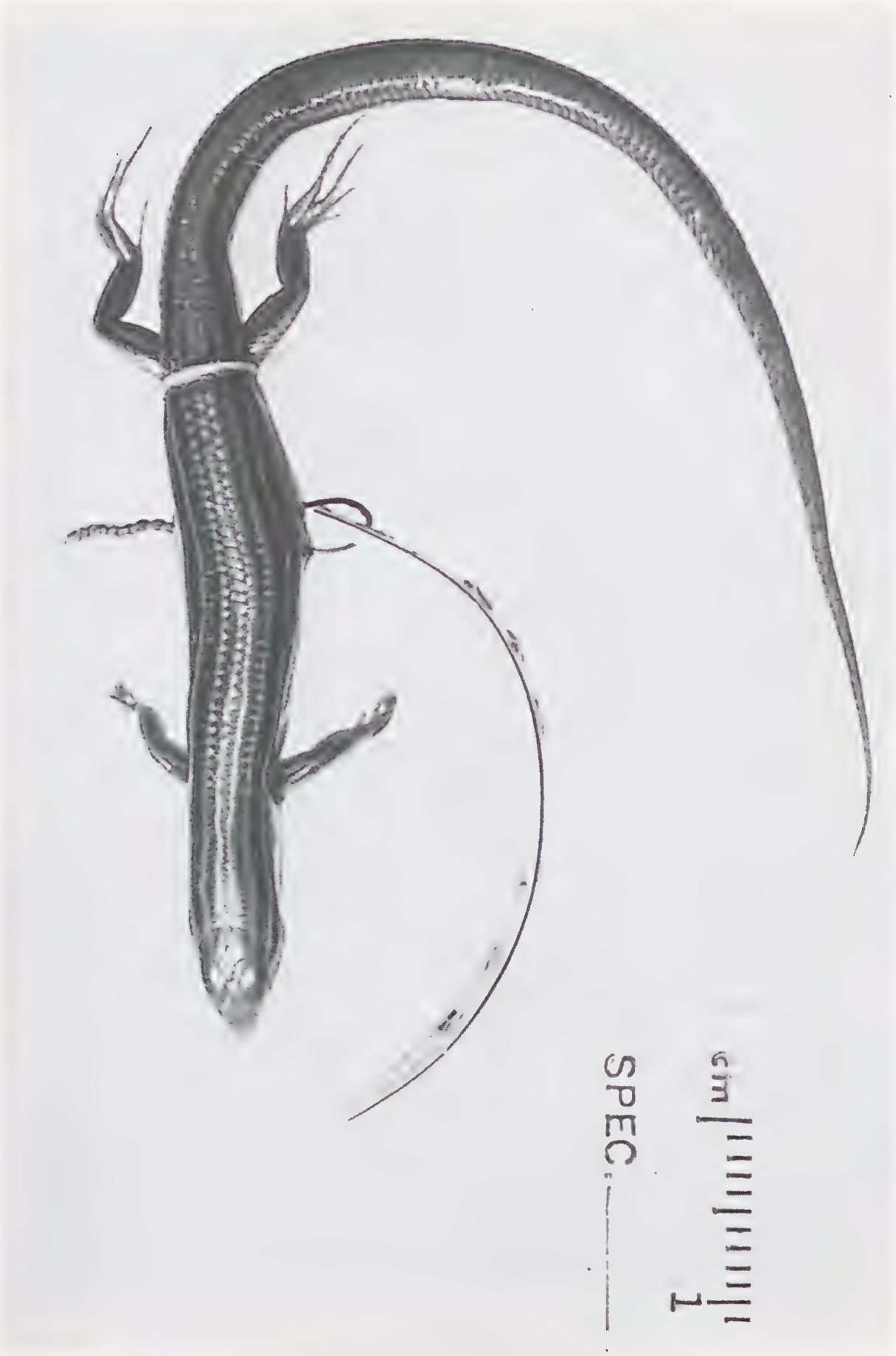

Fig. 2. Holotype of *Ctenotus storri*. (Photographed by G. Millen).

Fig. 3. A living specimen of *Ctenotus storri*, (AM R51993) from Adelaide River, N.T.

The 100 m contour (see map, Fig. 7) appears to be well correlated with the edge of the flat coastal areas in which the species has been collected and may be taken as an arbitrary limit upon the southern expansion of the species' range. At Adelaide River township, *Ctenotus essingtoni* was found by the author to be common and syntopic with *C. storri*, but seemed to prefer to burrow and hide under logs, rocks and rubbish rather than burrow or live in the open as appears to be the case with *C. storri*.

Ctenotus decaneurus decaneurus
Figs 4, 5, 6, 7

Ctenotus decaneurus (part) Storr 1970, J. Proc. R. Soc. West. Aust., 52 (4): 104.

Ctenotus decaneurus (part) Storr 1975, Rec. West. Aust. Mus., 3 (3): 234.

DIAGNOSIS: *Ctenotus decaneurus* is a small member of the *taeniolatus* species group with a total of 10 (8 when ventro-lateral missing) pale longitudinal body stripes and no pale spots or flecks in the dorsal and lateral pattern. Dinstinguished from all subspecies of *C. quattuordecimlineatus* and from *C. dux* and *C. ariadnae* by separated prefrontals and fewer pale longitudinal stripes, resulting in an absence of white upper lateral lines between white dorso-lateral and mid-lateral stripes. Distinguished from both subspecies of *C. piankai* by presence of a pale longitudinal stripe between paravertebrals and dorso-laterals, from *C. impar* by lack of pale vertebral stripe or pale temporal streak, from *C. taeniolatus* by absence of a broad light brown stripe between paravertebrals and dorso-laterals, and from *C. storri* by regularity of pattern (no stripes coalescing) and absence of broadly enlarged upper ear lobule.

VARIATION IN MATERIAL EXAMINED: Meristics and measurements are included in Table 1. The nasals contact in 10 (59%) of the 17 specimens examined, with the remainder having them moderately separated. In all but one of the specimens examined the prefrontals are widely separated (WAM R43526 has them in short contact) and there are 4/4 supraoculars with 3/3 contacting the frontal except for AM R51960 in which there are only 2/2 contacting the frontal. Toe nails moderately recurved (see Fig. 4).

Colour and pattern: The following description is based on a specimen in life. With respect to patterning, it conforms closely to Storr's (1970) description of the holotype. Base colour of dorsal surface of head coppery brown with black longitudinal blotches between the beginnings of pale body stripes. Supralabials grey with darker edges. Base colour of body black with 10 distinct pale stripes. The dorsal stripes are coppery brown anteriorly, merging to white posteriorly. The lateral stripes are white for their whole lengths. Base colour of the limbs off-white, striped longitudinally black. Soles of feet pink to light brown. Tail grey-brown striped with off-white. Venter immaculate white.

All but one of the specimens examined conformed closely to the colour description given by Storr, subject to changes in alcohol. The most obvious source of variation was in the presence or absence of a pale ventro-lateral stripe. This character was found to be lacking in only 4 (25%) of 16 specimens examined.

The only exception to the normal colour and pattern is WAM R50505. In alcohol, its colour and pattern is as follows: A total of 12 longitudinal white stripes around the body, including ventro-laterals and other normal stripes of *C. decaneurus*. The white stripe between paravertebral and dorso-lateral has another white stripe very close to and parallel to its outer margin. The dorsal stripes are all indistinct and irregular, the lateral stripes distinct and normal. More black on head than normal *C. decaneurus*. Supralabial stripe very distinct, beginning on first loreal and extending back over ear aperture. Pattern on tail more broken than in normal *C. decaneurus*. Whether or not this specimen represents an aberrant individual or a local variant is not clear.

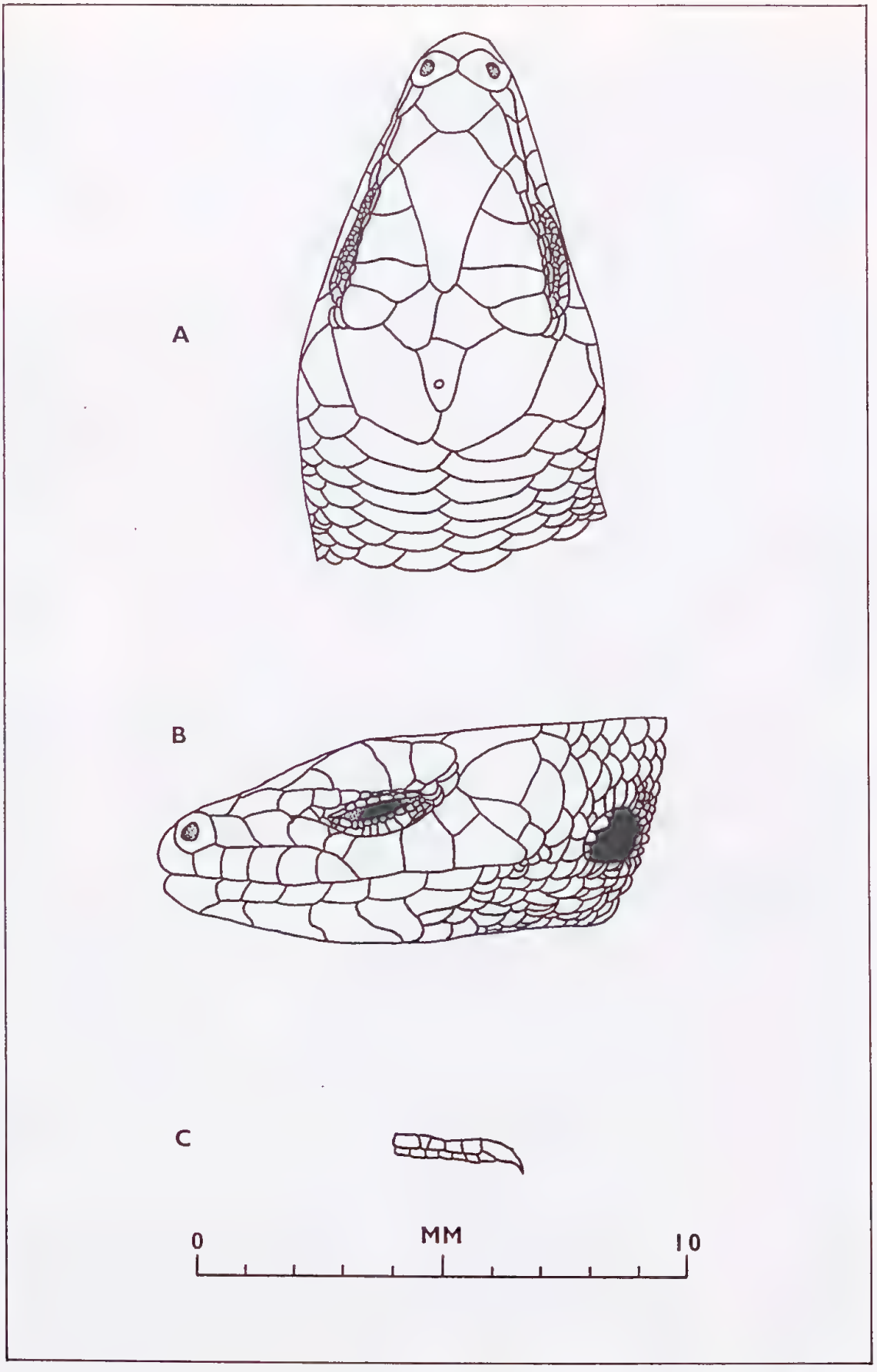

Fig. 4. Holotype of *Ctenotus decaneurus* (WAM R23130). A. Dorsal aspect of head. B. Left lateral aspect of head. C. Lateral aspect of tip of fourth toe on left hind limb.

Geographical variation: The specimens in the series from Mt. Carr (the only locality in the Northern Territory from which material is available) differ from the Western Australian material in the following respects. They all have separated nasals, 24 mid-body scale rows and shorter limbs. The western specimens all have contiguous nasals, and 26 mid-body scale rows. Of further possible significance is that all of the specimens lacking ventro-lateral stripes came from western populations. Whether any of these differences may be taken as indicators of an east-west cline remains to be seen when more specimens are available.

DISTRIBUTION: Probably restricted to the rocky hills of the north-western Northern Territory, and the north and north-east Kimberley region of Western Australia.

HABITAT AND ECOLOGY: The only locality where the author has seen this species is Mt. Carr, Adelaide River, Northern Territory. The habitat at this site consists of stony hills with very steep sides. The main rock type is conglomerate. The vegetation on Mt. Carr is essentially a deciduous broadleaf savanna woodland, and at the times of the author's visits (September-October 1975) there was very little live ground cover such as grass.

Three of the four specimens encountered by the author were on the very steep south-western aspect of the hill and the other, a juvenile, was on the relatively flat summit. All were active when discovered, and attempted to escape into rock crevices or under rocks loosely fitting on the ground. The dates and approximate times of collection of the specimens taken by the author and others present (P. Horner and G. Gow) were as follows: Mid-morning 25th September, 1975, one adult specimen; mid-day 2nd October, 1975, two specimens — one adult, one juvenile. A further example of the species was observed during the very late afternoon of 24th September.

None of the animals seen attempted to escape into a burrow. The hard stony soil would probably make burrow construction difficult and the presence of numerous rock crevices may negate the necessity of burrowing.

The melanistic colouring of the species (see Fig. 6) may contribute to effective thermoregulation (Parker, 1935).

MATERIAL EXAMINED: Where localities are not cited below, they have already been provided by Storr (1975). Western Australian Museum: R23130; R43152; R43162; R43188; R43247; R43526; R45559; R50505 Drysdale River National Park, W.A., in Lat: 14°48'S, Long: 126°57'E. Australian Museum: R45599 (formerly WAM R45596); R51960 Mt. Carr, Adelaide River, N.T. in Lat: 13°15'S, Long: 131°06'E. Northern Territory Museum, Darwin, N.T.: R1275-6, R2053-6 Mt. Carr, Adelaide River, N.T. in Lat 13°15'S, Long: 131°06'E. National Museum of Victoria: D41623 (formerly WAM R45595).

Ctenotus decaneurus yampiensis

Ctenotus decaneurus yampiensis Storr 1975, Rec. West. Aust. Mus., 3 (3): 235.

DIAGNOSIS: *C. d. yampiensis* is similar in most respects to *C. d. decaneurus* from which it may be distinguished by its higher number of mid-body scale rows (29-32).

COMMENT: Unfortunately, none of the type series was available for the author's examination (G. Storr, pers. comm.), but two other specimens not used in the description were examined. Their meristics and measurements are presented in Table 1. In both specimens the nasals are moderately separated, prefrontals are separate in one, and in short contact in the other (R11741). Supraoculars 4/4, 3/3 contacting the frontal in both specimens. Toe nails moderately recurved. The colour pattern appears to be identical to the nominate race.

MATERIAL EXAMINED: Western Australian Museum: Wotjulum, W.A., in Lat: 16°11'S, Long: 123°37'E (R11740-1).

Fig. 5. Holotype of *Ctenotus decaneurus*. (Photographed by G. Millen).

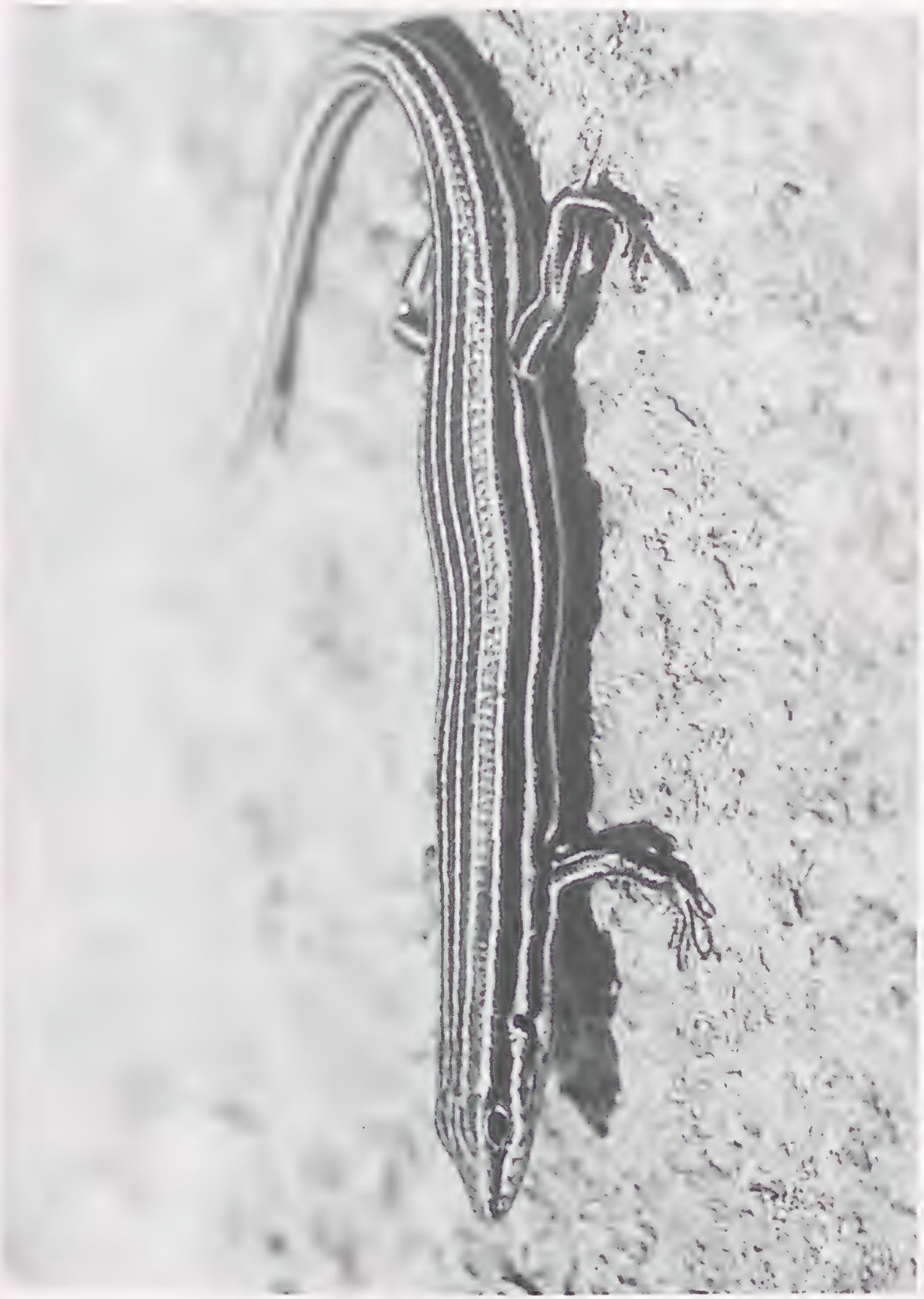

Fig. 6. A living specimen of *Ctenotus d. decaneurus* (NTM R1275) from Mt. Carr, Adelaide River, N.T.

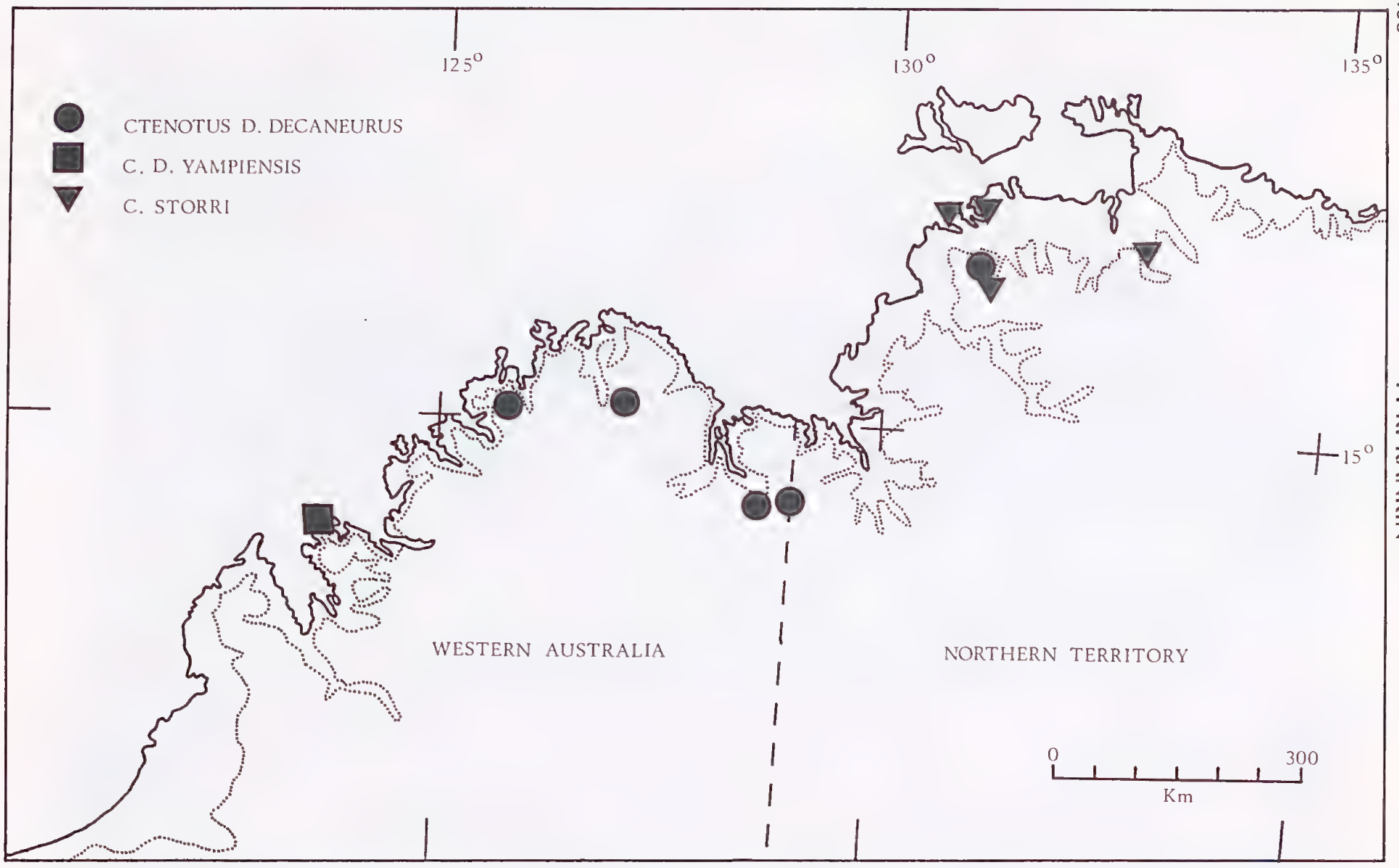

Fig. 7. Known localities of *Ctenotus storri, C. d. decaneurus,* and *C. d. yampiensis*. The dotted line represents the 100 metre contour.

DISCUSSION: The specimen AM R13005 was originally designated by Storr (1970) as the only paratype of *Ctenotus decaneurus*. It has been shown above that this specimen is not conspecific with the holotype. Storr (1975) subsequently mistook two other specimens of *C. storri* for *C. decaneurus*, ANWC R745 (formerly NTR 303) and ANWC R746 (formerly NTR 233). No mention was made in either of Storr's papers of any variation in colour pattern or scalation between the specimens now designated as *C. storri* and the holotype of *C. decaneurus* other than the enlarged upper ear lobules of *C. storri*.

The recent collection of specimens of *Ctenotus decaneurus* and *Ctenotus storri* with no intergradation less than one kilometre apart at Adelaide River, N.T. leaves little doubt that *C. storri* is not merely an eastern geographical form of *C. decaneurus*.

In *Ctenotus decaneurus* there is an increase in mid body scale rows, and length of appendages from East to West, with *C. d. yampiensis* representing an upper limit in these respects. The high values in appendage sizes of the Western Australian *C. d. decaneurus* material (see Table 1) are accounted for by the presence of a juvenile specimen which has relatively larger appendages than adults. The *C. d. yampiensis* population is the only one in the species' range presently known to exhibit variation in the number of mid body scale rows. It is of interest to note that the populations of *C. decaneurus* from the extreme east and west of the species' currently known range have a character in common which appears to be absent from the intervening populations, namely the separation of the nasals. A consequence of this is the loss of one diagnostic feature of *C. d. yampiensis*.

ACKNOWLEDGEMENTS

I am most grateful to Dr. H. G. Cogger for providing the facilities to carry out this study, and for his constant encouragement and critical evaluation of the work at all its stages. I am further indebted to Mr. J. Coventry, Mr. G. Gow, Dr. G. M. Storr, and Mr. J. Wombey for allowing me to examine specimens in their care, and to Mr. K. Martin, without whose hospitality my field work in the Darwin area would have been far less enjoyable. Thanks are also due to Mrs. A. Young for typing the manuscript.

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Storr, G. M. (1970) The genus *Ctenotus* (Lacertilia, Scincidae), in the Northern Territory. J. Proc. R. Soc. West. Aust., 52 (4): 97-108.

Storr, G. M. (1971) The genus *Ctenotus* (Lacertilia, Scincidae), in South Australia. Rec. S. Aust. Mus., 16 (6): 1-15.

Storr, G. M. (1974) The genus *Ctenotus* (Lacertilia, Scincidae) in the South-west and Eucla Divisions of Western Australia. J. Proc. R. Soc. West. Aust., 56 (3): 86-93.

Storr, G. M. (1975) The genus *Ctenotus* (Lacertilia, Scincidae) in the Kimberley and North-west Divisions of Western Australia. Rec. West. Aust. Mus., 1975, 3 (3): 209-243.

Manuscript accepted for publication 17 March, 1977

Table 1: Variation in ranges of meristics and measurements of the species discussed in this paper, using all specimens available. Means are indicated in brackets. Measurements are expressed as percentages of SVL which is in mm. The figure in brackets in the number column (N) is the number of specimens with original tails.

	N	SVL	Tail	Fore-leg	Hind-leg	Axilla-groin	Snout-fore-limb	Mid-Body scale rows	Lamellae under 4th toe	Supra-ciliar-ies	Supra-labials	Ear lobul-es	Nuch-als
C. storri	*7 (4)*	21-40.5	175-192	25-35	45-52	46-53	32-42	24-26	21-24	6-8	6-7	1-5	4-3
		(30.2)	*(187.5)*	*(29.0)*	*(48.0)*	*(49.8)*	*(37.8)*	*(25.3)*	*(22.5)*	*(6.7)*	*(6.9)*	*(2.7)*	*(3.6)*
C. d. decaneurus		25.5-46	157-239	25-31	39.5-48	46-53	32-47	24	20-21	7-8	7-8	3-6	4
Mt. Carr series	7 (6)	(39.8)	(215.0)	(27.0)	(43.5)	(49.0)	(36.8)	(24.0)	(20.6)	(7.9)	(7.4)	(4.6)	(4)
C. d. decaneurus		*19-47*	*165-230*	*25-47*	*43-63*	*47-54*	*34-58*	*26*	*18-24*	*7-8*	*7-8*	*2-6*	*3-5*
W. A. Material	*10 (5)*	*(38.2)*	*(197.0)*	*(30.8)*	*(47.8)*	*(50.4)*	*(39.7)*	*(26.0)*	*(21.4)*	*(7.6)*	*(7.5)*	*(4.4)*	*(3.5)*
C. decaneurus		49-51	178	29-31	47-49	46-53	38	29-32	21-22	8	8	3-4	3-5
yampiensis	2 (1)	(50.0)	(178.0)	(30.0)	(48.0)	(49.5)	(38.0)	(30.5)	(21.5)	(8.0)	(8.0)	(3.8)	(3.8)

ADDENDUM

In January, 1977, the author collected a juvenile (SVL = 22 mm) *Ctenotus storri* at Mandorah, Cox Peninsula, N.T. in Latitude: 12°27'S; Longitude: 130°46'E. (Registration number: NTM R3125). This site is 15 km due East of Tapa Bay, the Type Locality. The habitat here is Tropical Layered Woodland interspersed with *Melaleuca* swamp and open grassy areas, adjoining an ocean beach.

The specimen was collected while active at 1130 hrs in an open grassy area during a short sunny break between heavy rain showers. In measurements and meristics, this juvenile is entirely within the ranges given for the species in Table 1; however, the colouring and patterning differ from those provided in the preceding description, and are described below.

COLOUR AND PATTERN (in life): Base colour of head and dorsum bright yellow. A total of eight pale dorsal and lateral stripes. A prominent black mid-frontal streak extending from frontoparietals to frontonasal. A distinct narrow black vertebral stripe beginning on nape and extending irregularly back the level of the hindlimbs. Paravertebrals bright yellow, narrow, beginning as one just anterior to the commencement of the vertebral stripe on the nape, joining at about the level of the hindlimbs, and extending down the tail (broken about half way along) where they are pale brown. A bright yellow longitudinal stripe between the paravertebral and dorso-lateral stripes, beginning on supraoculars and as extensions of yellow edge of black midfrontal streak, terminating at base of tail and separated from paravertebral by a black intermediate zone. A narrow, bright yellow dorso-lateral stripe beginning on outer edge of supraoculars and extending at least half way down tail, separated from dorsal stripes by a moderately wide black stripe beginning on supraoculars and extending for at least half the length of the tail. Upper lateral zone black, beginning on lores and extending for at least half the length of the tail. A distinct white unbroken temporal streak beginning posterior to the eye, extending to the ear aperture where it meets the mid-lateral stripe. A well-defined white mid-lateral stripe, beginning on supralabials, looping over ear aperture, and extending uninterrupted along the body on to the tail, for at least half its length, bordered below by a broad black stripe beginning at ventral edge of ear aperture and extending to hindlimb. Beginning of another black stripe which would enclose a pale ventro-lateral stripe below forelimb and extending posteriorly for about one third of the area from axilla to groin. Ventral surface immaculate white, excepting for underside of tail and limbs which are pink. Upper surface of limbs pale brown striped longitudinally dark brown to black.

A CATALOGUE OF THE TYPE SPECIMENS OF DIPTERA IN THE AUSTRALIAN MUSEUM

GREG DANIELS

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The following names occur in this catalogue as new combinations:

Cerioides euphara Riek	= *Ceriana euphara* (Riek)
Cerioides alboseta Ferguson	= *Ceriana alboseta* (Ferguson)
Cerioides platypus Ferguson	= *Ceriana platypus* (Ferguson)
Cerioides apicalis Ferguson	= *Ceriana apicalis* (Ferguson)
Cerioides mastersi Ferguson	= *Ceriana mastersi* (Ferguson)
Cerioides alaplicata Hardy	= *Ceriana alaplicata* (Hardy)
Strumeta aquilonis May	= *Dacus aquilonis* (May)
Strumeta tenuifascia May	= *Dacus tenuifascia* (May)
Hendelina australina Hardy	= *Myoleja australina* (Hardy)
Rioxa confusa Hardy	= *Dirioxa confusa* (Hardy)
Czernyola australis McAlpine	= *Craspedochaeta australis* (McAlpine)
Czernyola bisignata McAlpine	= *Craspedochaeta bisignata* (McAlpine)
Czernyola delta McAlpine	= *Craspedochaeta delta* (McAlpine)
Ephydroscinis raymenti Curran	= *Lasiopleura raymenti* (Curran)
Hypsomyia goilala McAlpine	= *Rhadinomyia goilala* (McAlpine)

INTRODUCTION

The Diptera type-collection in the Australian Museum comprises 3040 specimens representing 620 nominal species. Of the species represented 590 are Australian, 47 are from New Guinea and the Pacific Islands and seven are from other regions. According to published data, 10 type specimens representing nine species have not been located in the collection.

The terms "holotype", "paratype" and "syntype" are used in accordance with Article 73 of the International code of Zoological Nomenclature (1961). Although the term "allotype" is not recognised in the Code it has been used here because many of the types in the collection are labelled as such. The term refers to a single specimen of opposite sex to the holotype designated in the original description (Mayr, et al., 1953:239). Such specimens are now normally referred to as paratypes. So far as possible, specimens listed as paratypes have been checked with the original descriptions to ensure they were available to the author at the time the species was described.

Records of The Australian Museum, 1978, **Vol. 31, No. 11,** 411-471

Several workers, especially Hardy, Taylor and Ferguson, believed it possible to designate an "allotype" of another person's species. In the collection, 14 specimens of nine species were regarded as allotypes by these authors, but in fact the specimens have no type status.

Authors, such as Skuse, Ferguson and Hardy, labelled specimens as types without validly designating them as such. When the description of a species was based on more than one specimen and no holotype designated, in this catalogue these specimens are regarded as syntypes.

The catalogue is divided into three faunal areas, viz: Australia, being mainland Australia and Tasmania only; Pacific Islands, comprising New Guinea, New Hebrides, Norfolk Island, Lord Howe Island and New Zealand; and other regions of which only one or two species are represented.

The systematic arrangement follows the order given in Colless and McAlpine, 1970. The arrangement of genera and species within a family generally follows that given in the latest revision of the group concerned, but otherwise follows the organisation of the Museum collection.

The name under which each type was originally described is given, incorrect generic spellings not being noted. This is followed by details of the original publication and a full reference is provided at the end of the catalogue. Then follows a list of the types, sexes of specimens, type localities and the Museum registration number assigned to each type. Finally, if the original name has been changed, the name under which the species is presently placed is noted, together with details of the relevant publication.

There are many cases of discrepancy between the collection data as published and that appearing on the label. Wherever such instances have been detected they are here recorded. All distances recorded in the catalogue are given in kilometres, even though the collection data may be in miles. Throughout the catalogue subgeneric names are omitted.

The following abbreviations have been used throughout the catalogue: HT (holotype), AT (allotype), PT (paratype(s)) and ST (syntype(s)).

When the G.H.H. Hardy collection was presented to the Museum, it was found that many specimens had been severely damaged by *Anthrenus*, several specimens being represented by a pin bearing a slide with genitalia, collection data and a determination label. These damaged specimens are listed separately at the end of the catalogue.

AUSTRALIAN TYPES

Suborder NEMATOCERA
Division TIPULOMORPHA
Family TIPULIDAE
Subfamily LIMNOBIINAE

Geranomyia lutulenta Skuse, 1890:779.
ST ♀, Mount Kosciusko, N.S.W. K36766
Labelled "♀ type". The specimen is badly damaged.

Dicranomyia helmsi Skuse, 1890:763.
ST ♂, Mount Kosciusko, N.S.W. K36850
Labelled "♂ type".

Molophilus montivagus Skuse, 1890:808.
HT ♀ , Jindabyne, N.S.W. K36762

Molophilus helmsi Skuse, 1890:805.
ST ♂ , Kosciusko, N.S.W. K36763
Labelled "♂ type". This specimen is represented by the head and part of the thorax.

Teucholabis meridiana Skuse, 1890:798.
HT ♂ , Victoria K36859
This specimen is represented by a wing and one leg mounted on a slide.

Rhypholophus maculosus Skuse, 1890:802.
HT ♀ , Mount Kosciusko, N.S.W. K36761

Limnophila imitatrix Skuse, 1890:847.
ST 1♂ , 1♀ , Kosciusko, N.S.W. K36759
Labelled "type ♂ " and "type ♀ ". The ♂ specimen is in poor condition.

Limnophila fergusoni Alexander, 1923:384.
HT ♂ , Mount Kosciusko, N.S.W. K48205

Limnophila serraticornis Alexander, 1923:386.
HT ♀ , Blue Mountains, N.S.W. K48204

Limnophila aurantiipennis Alexander, 1923:386.
HT ♀ , Blue Mountains, N.S.W. K48203

Limnophila pauciseta Alexander, 1924b:508.
HT ♂ , Blue Mountains, N.S.W. K49464

Paralimnophila fraudulenta Alexander, 1924b:512.
HT ♀ , Blue Mountains, N.S.W. K49463

Gynoplistia viridithorax Skuse, 1890:882.
HT ♀ , Moonbar, N.S.W. K36757

Gynoplistia fergusoniana Alexander, 1924b:516.
HT ♂ , Blue Mountains, N.S.W. K49468

Gynoplistia bimaculata nigrotibialis Alexander, 1924b:515.
HT ♂ , Blue Mountains, N.S.W. K49467

Gynoplistia patruelis Alexander, 1924b:513.
HT ♂ , Mount Kosciusko, N.S.W. K49466

Gynoplistia bella atripes Alexander, 1924b:514.
HT ♀ , Kosciusko, N.S.W. K49469

Subfamily TIPULINAE

Dolichopeza longidigitalis Alexander, 1924:182.
HT ♂ , AT ♀ , Blue Mountains, N.S.W. K48201-2
This is a synonym of *Dolichopeza cinerea* (Macquart) (Dobrotworsky, 1974c:7).

Clytocosmus helmsi Skuse, 1890a:76.
ST 2♂, Moonbar, N.S.W. K70503
One specimen labelled "type ♂ ", this specimen having the head and five legs missing.

Clytocosmus alexanderi Dobrotworsky, 1968a:509.
HT ♂ , National Park, McPherson Range, Qld. K68654

Platyphasia rawlinsoni Dobrotworsky, 1971:9.
PT ♀ , Smiggin Holes, Mount Kosciusko, N.S.W. K70504

Platyphasia princeps Skuse, 1890a:85.
HT♂ , Moonbar, N.S.W. K36765

Acracantha inornata Skuse, 1890a:113.
HT♀ , King George Sound, W.A. K36767

Polymoria electa Alexander, 1924b:506.
HT♀ , Blue Mountains, N.S.W. K49465

Ischnotoma immaculipennis Alexander, 1924:186.
HT♀ , Blue Mountains, N.S.W. K48197
Dobrotworsky (1971a:40) states the holotype is lost.

Ischnotoma episema Alexander, 1924:184.
HT♀ , Mount Kosciusko, N.S.W. K48198

Ischnotoma scutellumnigrum Alexander, 1924:185.
HT♂ , AT♀ , Mount Kosciusko, N.S.W. K48199-200

Ischnotoma goldfinchi Alexander, 1924b:520.
HT♂ , Kosciusko, N.S.W. K49462

Habromastix cinerascens Skuse, 1890a:94.
Paralectotype ♂ , Moonbar, N.S.W. K70405
Leptotarsus cinerascens (Skuse) (Dobrotworsky, 1974a:16).

Macromastix tenuirostris Alexander, 1924a:377.
HT♂ , Taree, N.S.W. K48196
Dobrotworsky (1974:11) states the holotype is lost.
Leptotarsus tenuirostris (Alexander) (Dobrotworsky, 1974:11).

Macromastix luteicosta Alexander, 1924:193.
HT♂ , PT 3♂ , Blue Mountains, N.S.W. K48191
Leptotarsus luteicostus (Alexander) (Dobrotworsky, 1974b:45).

Macromastix fergusoni Alexander, 1924:192.
HT♂ , PT 5♂ , Blue Mountains, N.S.W. K48190
Leptotarsus fergusoni (Alexander) (Dobrotworsky, 1968:485).

Macromastix albicollis Alexander, 1924:188.
HT♀ , PT♀ , Blue Mountains, N.S.W. K48192
Leptotarsus albicollis (Alexander) (Dobrotworsky, 1974b:46).

Macromastix aurantioceps Alexander, 1924:190.
HT♀ , Megan, E. Dorrigo, N.S.W. K48194
Leptotarsus aurantioceps (Alexander) (Dobrotworsky, 1974b:56).

Macromastix aurantioceps subnitida Alexander, 1924:192.
HT♀ , PT 2♀ , Blue Mountains, N.S.W. K48195
Leptotarsus aurantioceps (Alexander) (Dobrotworsky, 1974b:56).

Macromastix obscurirostris Skuse, 1890a:135.
ST♂ , Kosciusko, N.S.W. (Labelled "type ♂"). K36764
ST♀ , Kosciusko, N.S.W. (Labelled "type ♀"). K36851
Leptotarsus obscurirostris (Skuse) (Dobrotworsky, 1974b:41).

Leptotarsus barringtoniensis Dobrotworsky, 1974b:48.
PT♂ , Barrington House, N.S.W. K70406

Macromastix dorrigensis Alexander, 1924:189.
HT♀ , Lowanna, E. Dorrigo, N.S.W. K48193
Leptotarsus dorrigensis (Alexander) (Dobrotworsky, 1974b:51).

Macromastix helmsi Skuse, 1890a:132.
Lectotype ♂ , paralectotype ♀ , Mount Kosciusko, N.S.W. K36858
Leptotarsus helmsi (Skuse) (Dobrotworsky, 1974b:36).

Leptotarsus gargettensis Dobrotworsky, 1974b:52.
HT♂ , Gargett, near Mackay, Qld. K70507

Division PSYCHODOMORPHA
Family PSYCHODIDAE

Telmatoscopus aberrans Tonnoir, 1953:441.
PT♂ , Eaglehawk Neck, Tas. K67607

Telmatoscopus viduatus Tonnoir, 1953:439.
PT♂ , Burnie, Tas. K67609

Telmatoscopus variegatus Satchell, 1953:394.
PT♂ , Hobart, Tas. K67606

Telmatoscopus festivus Satchell, 1953:399.
PT 1♂, 1♀ , Fitzroy Falls, N.S.W. K67612-3

Atrichobrunettia alternata Satchell, 1953:413.
PT♀ , Blundell's, A.C.T. K67603
PT♀ , Ferntree Gully, Vic. K67604
PT♂ , Burnie, Tas. K67605

Pericoma albipes Tonnoir, 1953:427.
PT♂ , Waterfall, N.S.W. K67602

Pericoma illustrata Tonnoir, 1953:422.
PT♀ , Mount Wellington, Tas. K67600

Pericoma intricatoria Tonnoir, 1953:430.
PT♂ , Blundell's, A.C.T. K67601

Notiocharis dimorpha Satchell, 1953:364.
PT♂ , Blundell's, A.C.T. K67597
PT♀ , Burnie, Tas. K67598
The Blundell's specimen is labelled *Pericoma dimorpha albipes* Tonn. Paratype.

Division CULICOMORPHA
Family DIXIDAE

Dixa nicholsoni Tonnoir, 1923:64.
HT♂ , Allyn River, N.S.W. K49120

Family CULICIDAE

Hodgesia cairnsensis Taylor, 1919:842.
PT♀ , Cairns, Qld. K42254

Family SIMULIIDAE

Simulium ornatipes Skuse, 1890c:632.
ST 2♂, 2♀ , near Louth, Darling River, N.S.W. K36731
The two male specimens are mounted on separate pins and the two female specimens are mounted on a common card. One of the males bears a locality label in Skuse's handwriting and also has a small round red label attached. This specimen has been remounted. The other three specimens (on two pins) have locality labels presumably written by Musgrave. The females have been remounted and bear a written allotype label, as well as a small round blue label, whilst the male is affixed to its original mount. I have assumed that Skuse's specimens were remounted and relabelled by Musgrave.

Simulium fergusoni Tonnoir, 1925:238.
HT♀ , Bumberry, N.S.W. K48711
Cnephia fergusoni (Tonnoir) (Mackerras and Mackerras, 1949:386).
Mackerras and Mackerras (1949:386) state that the location of the type is not known.

Simulium aurantiacum Tonnoir, 1925:234.
PT 3♀ , Mount Wilson, N.S.W. K51170
PT♂ , Sassafras, Vic. K51171
Cnephia aurantiacum (Tonnoir) (Smart, 1945:498).

Austrosimulium cornutum Tonnoir, 1925:243.
PT 2♀ , Sassafras, Vic. K51172
PT♀ , Burnie, Tas. K51173
PT♀ , Strahan, Tas. K51174

Austrosimulium weindorferi Tonnoir, 1925:248.
PT 3♀ , Cradle Valley, Tas. K51179
This is a synonym of *Austrosimulium furiosum* (Skuse) (Mackerras and Mackerras, 1949:397).

Austrosimulium torrentium Tonnoir, 1925:247.
PT 1♂ , 1♀ , Launceston, Tas. K51178

Division BIBIONOMORPHA
Family PERISSOMMATIDAE

Perissomma fusca Colless, 1962:525.
PT 1♂, 1♀ , Mount Majura, A.C.T. K68248-9

Perissomma mcalpinei Colless, 1962:528.
HT♀ , Mount Wilson, N.S.W. K68250

Family BIBIONIDAE

Dilophus varipes Skuse, 1890c:635.
ST 9♂, Kosciusko, N.S.W. K70520
A pin with two carded specimens bears the label "Type". The remainder have similar locality labels to the specimens labelled type.

Family SCIARIDAE

Sciara infixa Skuse, 1890b:400.
HT♀ , Mount Kosciusko, N.S.W. K36717

Sciara helmsi Skuse, 1890b:408.
ST 2♀ , Mount Kosciusko, N.S.W. K36718
One specimen is labelled "♀ type". The other specimen has a similar locality label as the specimen labelled type.

Sciara serenipennis Skuse, 1890b:402.
ST♂ , Mount Kosciusko, N.S.W. K36719
Labelled "♂ type". This specimen is represented by three legs, a wing and part of the abdomen.

Sciara tepperi Skuse, 1890:393.
ST♀ , Adelaide, S.A. K36720
Labelled "♀ type".

Sciara contermina Skuse, 1890b:395.
ST♀ , Kosciusko, N.S.W. K36721
Labelled "♀ type".

Sciara promiscua Skuse, 1890b:394.
ST♀ , Kosciusko, N.S.W. K36722
Labelled "♀ type".

Family MYCETOPHILIDAE

Sciophila mccoyi Skuse, 1890c:606.
ST♀ , Victoria K36716
Labelled " ♀ type".
Mycomyia mccoyi (Skuse) (Tonnoir, 1929:599).

Clastobasis tryoni Skuse, 1890c:619.
ST♀ , Brisbane, Qld. K2319
Labelled " ♀ type".

Arachnocampa richardsae Harrison, 1966:881.
HT♂ , PT 1♂ , 2♀ , Newnes railway tunnel, N.S.W. K68575-8
PT♂ , Hazelbrook, Blue Mountains, N.S.W. K68579

Suborder BRACHYCERA
Division ORTHORRHAPHA
Superfamily TABANOIDEA
Family PELECORHYNCHIDAE

Pelecorhynchus olivei G. Hardy, 1933:413.
ST 1♂, 1♀ , Strahan, Tas. K70521
Labelled "HT" and "AT".

Pelecorhynchus igniculus G. Hardy, 1918:64.
ST 1♂, 1♀ , Cradle Mountain, Tas. K42683
Labelled "HT" and "AT".

Pelecorhynchus albolineatus G. Hardy, 1918:64.
ST 1♂, 2♀ , Cradle Mountain, Tas. K42684-5
Labelled "HT", "AT" and "PT".

Pelecorhynchus eristaloides subsp. *montanus* G. Hardy, 1916:269.
HT♂ , AT♀ , Mount Wellington, Tas. K42686
Pelecorhynchus montanus G. Hardy, 1918:65.

Pelecorhynchus occidens G. Hardy, 1933:414.
HT♂ , AT♀ , Cradle Mountain, Tas. K42687
Both specimens are labelled "*P. montanus* var. A." (G. Hardy, 1918:65) and were redescribed by Hardy as *P. occidens*.

Pelecorhynchus fulvus Ricardo, 1910:406.
There is, in the collection, a ♂ labelled allotype and described by Ferguson (1921:2), although not designated as the allotype by Ricardo or Ferguson. The species was originally described from a ♀ and this ♂ specimen cannot be an allotype.
1♂, Bright, Vic. K42742

Pelecorhynchus distinctus Taylor, 1918:53.
ST 2♀ , Dorrigo, N.S.W. K31966
Labelled "HT" and "PT"

Pelecorhynchus deuqueti G. Hardy, 1920a:38.
HT♀ , Blackheath, N.S.W. K42688

Pelecorhynchus tillyardi Taylor, 1918:54.
HT♀ , Dorrigo, N.S.W. K31967

Family RHAGIONIDAE

Chrysopilus mcalpinei Paramonov, 1962:121.
HT♂ , Kuranda, Qld. K68251

Chrysopilus androgynus Paramonov, 1962:123.
HT♂ , Williams River, Barrington Tops, N.S.W. K68252

Austroleptis rhyphoides G. Hardy, 1920:127.
HT♂ , AT♀ , PT 2♂, Mount Wellington, Tas. K42674

Austroleptis multimaculata G. Hardy, 1920:128.
HT♂ , Cradle Mountain, Tas. K42675

Spaniopsis longicornis Ferguson, 1915:242.
PT♀ , Gosford, N.S.W. (Labelled "cotype"). K68253

Spaniopsis marginipennis Ferguson, 1915:239.
HT♀ , Gosford, N.S.W. K42740
PT♀ , Gosford, N.S.W. (Labelled "cotype"). K42258

Spaniopsis tabaniformis White, 1914a:44.
ST 2♀ , Freycinet's Peninsula, Tas. K36468
Both specimens are labelled "cotype gen. & sp."
ST♀ , Freycinet's Peninsula, Tas. (Labelled HT). K70522

Spaniopsis vexans Ferguson, 1915:238.
PT 2♀ , Milson Island, N.S.W. K68254-5

Spaniopsis clelandi Ferguson, 1915:240.
HT♀ , Hawkesbury River, N.S.W. K42741
PT 2♀ , Blue Mountains, N.S.W. K68256-7

Dasyomma mcalpinei Paramonov, 1962:147.
HT♀ , Wentworth Falls, Blue Mountains, N.S.W. K68259

Dasyomma maculipennis G. Hardy, 1920:123.
HT♂ , AT♀ , PT 1♂ , 1♀ , Cradle Mountain, Tas. K42668

Dasyomma dissimilis G. Hardy, 1920:124
HT♂ , AT♀ , Cradle Mountain, Tas. K42666-7

Dasyomma hydrophila Paramonov, 1962:152.
HT♀ , Wentworth Falls, Blue Mountains, N.S.W. K68263

Atherimorpha vernalis occidens Hardy, 1927:126.
ST♂ , Strahan, Tas. (Labelled PT). K70697
This specimen has traces of mould.
Atherimorpha occidens Hardy (Paramonov, 1962:166).

Atherimorpha mcalpinei Paramonov, 1962:167.
HT♂ , Mount Wilson, Blue Mountains, N.S.W. K68263

Family TABANIDAE
Subfamily PANGONIINAE

Austroplex goldfinchi Mackerras, 1955:467.
PT 1♂, 1♀ , Mackay, Qld. K67856-7

Ectenopsis vulpecula var. *nigripennis* Taylor, 1918:63.
HT♀ , Norton's Basin, Nepean River, N.S.W. K39647
Ectenopsis vulpecula (Wiedemann) (Ferguson, 1921:11).

Ectenopsis australis Ricardo, 1917:217.
ST♀ , Sydney, N.S.W. K42729
Labelled "type".

Ectenopsis occidentalis Mackerras, 1956:425.
HT♂ , King George Sound, W.A. K67858

Demoplatus nigrovittatus Ferguson and Hill, 1920:460.
HT♂ , Kendall, N.S.W. K43468
Caenoprosopon nigrovittatus (Ferguson and Hill) (Henry, 1927:195).

Silvius minor Taylor, 1918:62.
ST 2♂, South Australia (Labelled "HT" and "PT") K40779
Caenoprosopon minor (Taylor) (Mackerras, 1956:440).

Therevopangonia insolita Mackerras, 1955:475.
PT♂ , Geraldton, W.A. K67859
PT♂ , Eradu, W.A. K67860

Erephopsis aureovestita Ferguson and Henry, 1920:834.
HT♀ , Kendall, N.S.W. K42731
Scaptia aureovestita (Ferguson and Henry) (Ferguson, 1926:295).

Scaptia aurinotum Mackerras, 1960:49.
HT♀ , Ebor, N.S.W. K70523

Diatomineura crocea Taylor, 1917:747.
ST♂ , Kuranda, Qld. (Labelled PT) K70524
This is a synonym of *Scaptia berylensis* (Ricardo) (Mackerras, 1960:53).

Scaptia auranticula Mackerras, 1960:54.
PT♂ , King George Sound, W.A. K36781

Scaptia alpina alpina Mackerras, 1960:67.
PT♂ , Yarrangobilly, N.S.W. K70535

Diatomineura fulgida Ferguson and Henry, 1920:837.
ST♀ , Kendall, N.S.W. (Labelled HT) K42730
Scaptia fulgida (Ferguson and Henry) (Enderlein, 1925:278).

Scaptia orientalis Mackerras, 1960:89.
PT 2♀ , Jervis Bay, A.C.T. K70525

Erephopsis vicina Taylor, 1918:57.
HT♂ , Wentworth Falls, Blue Mountains, N.S.W. K36658
Scaptia vicina (Taylor) (Ferguson, 1926:297).

Diatomineura regis-georgii Taylor, 1918:60.
ST♀ , King George Sound, W.A. K36783
Scaptia regisgeorgii (Taylor) (Enderlein, 1925:278).

Erephopsis neotricolor Taylor, 1918:55.
ST 2♀ , King George Sound, W.A. K36777
Labelled HT and PT
Scaptia neotricolor (Taylor) (Ferguson, 1926:297).

Erephopsis vicina var. *georgii* Taylor, 1918:57.
HT♀ , King George Sound, W.A. K36772
Scaptia georgii (Taylor) (Ferguson, 1926:296).

Diatomineura bicolorata Taylor, 1918:60.
ST 1♂, 1♀ , King George Sound, W.A. K36780
Scaptia bicolorata (Taylor) (Enderlein, 1925:278).

Scaptia calabyi Mackerras, 1960:106.
PT♀ , 28km SSE of Manjimup, W.A. K70527

Erephopsis xanthopilis Ferguson, 1921:7.
HT♀ , Hawkesbury River, N.S.W. K44005
Scaptia xanthopilis (Ferguson) (Ferguson, 1926:296).

Erephopsis subcontigua Ferguson, 1921:5.
HT♀ , Meldrum, N.S.W. K44003
Scaptia subcontigua (Ferguson) (Ferguson, 1926:296).

Erephopsis rufoniger Ferguson, 1921:6.
ST ♀ , Armidale, N.S.W. K44004
Scaptia rufoniger (Ferguson) (Ferguson, 1926:296).

Scaptia neoconcolor Mackerras, 1960:115.
PT ♀ , Kuranda, Qld. K70528

Erephopsis cinerea Ricardo, 1915:26.
There is, in the collection a ♂ labelled as the AT, and designated by Taylor (1918:55). As this specimen was not included in the type series it has no status as a type.
1 ♂, King George Sound, W.A. K36770
Scaptia cinerea (Ricardo) (Ferguson, 1926:298).

Erephopsis clelandi Ferguson, 1921:4.
HT ♀ , Narrabri, N.S.W. K44006
Scaptia clelandi (Ferguson) (Ferguson, 1926:298).

Subfamily CHRYSOPINAE

Silvius paraluridus Ferguson and Henry, 1920:839.
ST ♀ , Kendall, N.S.W. (Labelled "HT") K42933
Mesomyia paralurida (Ferguson and Henry) (Mackerras, 1955a:606).

Silvius sulcifrons Ferguson, 1921:14.
HT ♀ , Perth, W.A. K44407
Mesomyia sulcifrons (Ferguson) (Mackerras, 1955a:609).

Diatomineura cydister Taylor, 1918:58.
ST ♂ , King George Sound, W.A. (Labelled "HT") K37694
Mesomyia cydister (Taylor) (Mackerras, 1955a:609).

Subfamily TABANINAE

Tabanus wentworthi Ferguson and Hill, 1922:259.
HT ♂ , Blue Mountains, N.S.W. K47513
Cydistomyia wentworthi (Ferguson and Hill) (Mackerras, 1959:168).

Tabanus musgravii Taylor, 1918:64.
HT ♀ , Underbank, N.S.W. K37744
Cydistomyia musgravii (Taylor) (Mackerras, 1959:168).

Tabanus rivularis Ferguson and Hill, 1922:264.
ST ♀ , Kew, N.S.W. (Labelled "HT") K42735
Cydistomyia rivularis (Ferguson and Hill) (Mackerras, 1959:168).

Tabanus rainbowi Taylor, 1918:66.
HT ♂ , King George Sound, W.A. K37703
Dasybasis rainbowi (Taylor) (Mackerras, 1959:170).

Tabanus ochreoflavus Ferguson and Henry, 1920:845.
ST ♀ , Kendall, N.S.W. (Labelled "HT") K42739
Dasybasis ochreoflava (Ferguson and Henry) (Mackerras, 1959:173).

Tabanus tasmanicus Ferguson, 1921:20.
HT ♀ , Dunally, Tas. K44409
This is a synonym of *Dasybasis neocirrus* (Ricardo) (Mackerras, 1959:173).

Tabanus postponens Walker, 1848:179.
There is, in the collection, a ♂ labelled as the allotype, and designated by Taylor (1918:69). As this specimen was not included in the type series, it can have no status as a type.
1 ♂, Gayndah, Qld. K37702
Mackerras (personal comm.) writes saying the status of this specimen is uncertain.

Tabanus diemanensis Ferguson, 1921:25.
ST 1♂, 1♀, Bream Creek, Tas. K44410
Labelled "HT♀ " and "AT♂ ".
Dasybasis spadix diemanensis (Ferguson) (Mackerras, 1959:175).

Tabanus vespiformis Ferguson and Henry, 1920:840.
HT♀, Kendall, N.S.W. K42737
Dasybasis vespiformis (Ferguson and Henry) (Mackerras, 1959:175).

Tabanus pseudobasalis Taylor, 1918:68.
ST 2♀, King George Sound, W.A. K37699
Labelled "HT" and "PT"
This is a synonym of *Dasybasis postica* (Wiedemann) (Mackerras, 1959:176).

Tabanus trilinealis Ferguson and Henry, 1920:841.
ST♀, Kendall, N.S.W. (Labelled "HT") K43736
Dasybasis trilinealis (Ferguson and Henry) (Mackerras, 1959:178).

Tabanus kewensis Ferguson and Henry, 1920:843.
ST♀, Kew, N.S.W. (Labelled "HT") K42738
Dasybasis kewensis (Ferguson and Henry) (Mackerras, 1959:178).

Tabanus neolatifrons Ferguson and Hill, 1922:264.
HT♀, AT♂, Cradle Mountain, Tas. K44408
Dasybasis neolatifrons (Ferguson and Hill) (Mackerras, 1959:180).

Tabanus imperfectus Walker, 1848:179.
There is, in the collection, a ♂ labelled allotype and designated by Taylor (1918:66). As this specimen was not included in the type series, it cannot be considered to be a type.
1♂, Wedge Bay, Tas. K38462
Dasybasis imperfecta (Walker) (Mackerras, 1959:180).

Tabanus indefinitus Taylor, 1918:68.
ST♀, Nepean River, N.S.W. (Labelled "HT") K41041
Dasybasis dubiosa indefinita (Taylor) (Mackerras, 1959:181).

Tabanus innotatus Ferguson and Henry, 1920:847.
ST♀, Kendall, N.S.W. (Labelled "HT") K42734
Dasybasis innotata (Ferguson and Henry) (Mackerras, 1959:183).

Family STRATIOMYIDAE
Subfamily CHIROMYZINAE

Metoponia gemina G. Hardy, 1921a:535.
HT♀, AT♂, Leura, N.S.W. K43463
Inopus geminus (Hardy) (Nagatomi and Yukawa, 1968:523).

Boreoides subulatus G. Hardy, 1921a:540
PT 3♀, Bago Forest, via Batlow, N.S.W. K39952
PT♂, Kosciusko, N.S.W. K70530
PT♂, Moonbar, N.S.W. K70531

Subfamily ANTISSINAE

Lecogaster cyanea White, 1916:79.
This species was described from 2 ♀ collected at Milson Island, Hawkesbury River, N.S.W. There is, in the collection, a ♀ from Brisbane, Qld, labelled paratype, which cannot be considered to be a type as it was not included in the type series.
1♀, Brisbane, Qld. K67723
Lecomyia cyanea (White) (Hardy, 1932a:45).

Lecomyia notha G. Hardy, 1932a:46.
ST 2♂, Brisbane, Qld (Labelled PT) K67722

Subfamily STRATIOMYINAE

Odontomyia carinifacies var. *minima* G. Hardy, 1920d:55.
ST 2♀, Mount Wellington, Tas. K43451
Labelled "HT" and "AT".
This is a synonym of *Odontomyia stricta* Erichson (G. Hardy, 1938:72).

Odontomyia carinifacies var. *grandimaculata* G. Hardy, 1920d:56.
ST♂, Lymington, Tas. (Labelled "HT") K43450
ST 2♀, Bream Creek, Tas. (Labelled "PT") K43450
Odontomyia grandimaculata Hardy (G. Hardy, 1938:72).

Subfamily PACHYGASTRINAE

Pachygaster whitei G. Hardy, 1920d:44.
HT♀, AT♂, Hobart, Tas. K43458
Damaromyia whitei (Hardy) (G. Hardy, 1931:126).

Pachygaster nitens G. Hardy, 1922:194.
HT♀, National Park, Qld K45269
Damaromyia nitens (Hardy) (G. Hardy, 1931:125).

Dochmiocera aurilineata G. Hardy, 1922:195.
HT♀, National Park, Qld K45268

Family XYLOMYIDAE

Solva laeta Daniels, 1977:456.
HT♂, Mulgrave River, 6km W of Gordonvale, Qld. K70379
PT♀, Iron Range, Qld. K70380

Family NEMESTRINIDAE

Trichophthalma bivittata var. *coerulea* Paramonov, 1953:267.
HT♂, AT♀, Gundamain, Port Hacking, near Sydney, N.S.W. K52173

Trichophthalma costalis apicalis Mackerras, 1925:512.
PT 2♂, King George Sound, W.A. K51998

Trichophthalma rufonigra Mackerras, 1925:513.
PT 1♂, 1♀, Barrington Tops, N.S.W. K53025

Trichophthalma subcostalis Mackerras, 1925:514.
HT♂, Tulka, S.A. K42952

Trichophthalma fusca Mackerras, 1925:516.
HT♂, AT♀, Gayndah, Qld. K52002

Trichophthalma punctata orientalis Mackerras, 1925:519.
PT♂, Barrington Tops, N.S.W. K53028

Trichophthalma confusa Mackerras, 1925:521.
PT 3♂, Como, N.S.W. K47031

Trichophthalma ruficosta Mackerras, 1925:522.
HT♂, King George Sound, W.A. K37155

Trichophthalma bivitta nigricosta Mackerras, 1925:524.
PT♀, Barrington Tops, N.S.W. K53029

Trichopthalma harrisoni Mackerras, 1925:525.
PT 1♂, 1♀, Barrington Tops, N.S.W. K53030

Trichophthalma griseolineata Mackerras, 1925:528.
HT♂ , AT♀ , South Australia K52003

Trichophthalma nigrovittata Mackerras, 1925:531.
PT 1♂, 1♀ , Barrington Tops, N.S.W. K53026

Trichophthalma bancrofti Mackerras, 1925:533.
PT♀ , Eidsvold, Qld. K53022

Family ACROCERIDAE

Panops flavipes Latreille, 1811:710.
Neotype ♀ , Lane Cove, N.S.W. K70533
Mesophysa flavipes (Latreille) (Brunetti, 1926:580).

Oncodes tenuipes Paramonov, 1957:542.
HT♂ , Victoria K70640
PT ♂, Gayndah, Qld. K70641

Oncodes hirtifrons Paramonov, 1957:543.
PT 6♂, 3♀ , Mount Kosciusko, N.S.W. K59897

Oncodes glomerosus Paramonov, 1957:544.
HT♂ , Spencer's Creek, Mount Kosciusko, N.S.W. K70642

Superfamily ASILOIDEA
Family THEREVIDAE

Acupalpa albitarsa Mann, 1929:24.
PT♂ , Brisbane, Qld. K70534

Psilocephala aggera Mann, 1933:327.
PT♀ , Chinchilla, Qld.
This specimen is represented by a pin bearing Mann's determination label.

Psilocephala duocoloris Mann, 1933:329.
PT♂ , Denman, N.S.W. K70537
This specimen has the abdomen and a wing missing.

Anabarrhynchus manni G. Hardy, 1955:178.
ST 1♂, 2♀ , Katoomba, N.S.W. K70538
Labelled "HT", "AT" and "PT".

Family SCENOPINIDAE

Scenopinus minutus Kelsey, 1969:78.
HT♂ , PT♂ , Bronte, N.S.W. K68436-7
PT♀ , Como, N.S.W. K68438

Paramonova brevipalpa Kelsey, 1970:127.
HT♀ , PT♀ , Euiowie, 97km N of Broken Hill, N.S.W. K70364-5

Family ASILIDAE
Subfamily DASYPOGONINAE

Broticosia calignea Daniels, 1975:185.
HT♂ , PT♀ , Tubrabucca, upper Hunter district, N.S.W. K70364-5

Stichopogon minor G. Hardy, 1934a:513.
ST 2♂, Collaroy, N.S.W. (Labelled "PT") K66877

Clinopogon maritima G. Hardy, 1934a:511.
ST♂ , Sydney, N.S.W. (Labelled "PT") K66875
ST♀ , Eden, N.S.W. (Labelled "PT") K66875

Bathypogon robustus Hull, 1956:97.
PT ♀ , Canberra, A.C.T. K70536

Questopogon lineatus Daniels, 1976:227.
PT 1♂, 1♀ , Carnarvon Range, Qld. K70366-7

Saropogon nigritarsus Hull, 1956a:131.
PT ♂ , Canberra, A.C.T. K70539

Subfamily LAPHRIINAE

Tricella calcar Daniels, 1975a:189.
HT ♂ , PT 1♂, 1♀ , Claudie River, near Mount Lamond, Qld. K70368-70

Subfamily ASILINAE

Ommatius levis White, 1916a:170.
HT ♂ , Launceston, Tas. K43187

Ommatius distinctus Ricardo, 1918:66.
PT ♂ , Eidsvold, Qld. K42885
PT ♂ , Kuranda, Qld. K42253

Neoaratus rosevillensis G. Hardy, 1935:183.
ST 1♂, 3♀ , Sydney, N.S.W. K52825
The ♂ has a Gibbons' "type" label.

Asilus illingworthi G. Hardy, 1922:196.
HT ♂ , AT ♀ , Cairns, Qld. K45267
Neoaratus illingworthi (Hardy) (G. Hardy, 1935:180).

Neoaratus bancrofti G. Hardy, 1935:180.
ST, Eidsvold, Qld. K70540
The abdomen is missing from this specimen.

Asilus genitalis G. Hardy, 1920c:252.
HT ♂ , Cairns, Qld. K43206
Neoaratus genitalis (Hardy) (G. Hardy, 1935:179).

Neoitamus maculatoides G. Hardy, 1920b:197.
HT ♂ , AT ♀ , Sydney, N.S.W. K43194

Cerdistus conformis G. Hardy, 1926:655.
ST 11♂, 2♀ , Sydney, N.S.W. K70542
This is a synonym of *Cerdistus varimystaceus* Macquart (G. Hardy, 1935a:414).

Neoitamus maculatus White, 1914:278.
ST ♀ , Armadale, W.A. (Labelled "HT") K43196

Neoitamus setosus G. Hardy, 1920b:199.
HT ♂ , AT ♀ , Roseville, N.S.W. K43199
PT ♂ , Katoomba, N.S.W. K43198
PT ♀ , Sydney, N.S.W. K43199
Cerdistus setosus (Hardy) (Hull, 1962:515).

Neoitamus abditus White, 1916a:178.
There are, in the collection, a ♂ labelled allotype and 2 ♂ and a ♀ labelled paratypes, and designated by Hardy (1920b:190). As these specimens were not included in the type series, they have no status as types.
2♂, Hobart, Tas. (Labelled "AT" and "PT") K43188
1♂, 1♀ , Melbourne, Vic. (Labelled "PT") K43188
This is a synonym of *Neocerdistus acutangularis* (Macquart) (G. Hardy, 1926:647).

Cerdistus australis Ricardo, 1918:62.
PT♂ , Sydney, N.S.W. K52774
Both wings are missing from this specimen.
This species is a synonym of *Cerdistus caliginosus* White (Hull, 1962:515).

Family MYDAIDAE

Diochlistus hackeri Paramonov, 1950:25.
PT♀ , no data. K70541

Diochlistus apollinosus Paramonov, 1950:23.
HT♀ , 655km E. W. Line, S.A.
This specimen has not been located in the collection.

Family BOMBYLIIDAE
Subfamily SYSTROPINAE

Systropus clavifemoratus G. Hardy, 1921b:61.
HT♂ , AT♀ , Blackheath, N.S.W. K44413
Zaclava clavifemoratus (Hardy) (Hull, 1973:250).

Subfamily CYRTOSIINAE

Pachyneres australis Malloch, 1924a:205.
HT♂ , Como, N.S.W. K57588
Glabellula australis (Malloch) (Hull, 1973:271).

Subfamily LOMATINAE

Docidomyia swani Paramonov, 1951:750
PT♀ , Fraser Park, N.S.W. K70543

Antonia roddi Paramonov, 1950a:530.
HT♀ , Lane Cove, near Sydney, N.S.W. K70639
The abdomen and head are missing from this specimen.

Subfamily PHTHIRIINAE

Phthiria hilaris Walker, 1852:194.
There are, in the collection, 2♂ specimens labelled allotype and paratype, and designated by Hardy (1921b:66). As these specimens were not included in the type series, they have no status as types.
1♂, Blackheath, N.S.W. (Labelled "AT") K44411
1♂, Blackheath, N.S.W. (Labelled "PT") K70639

Eclimus longipalpis G. Hardy, 1921b:63.
HT♂ , La Perouse, N.S.W. K44412
There is, in the collection, a ♀ labelled allotype, designated by Roberts (1929:577). As this specimen was not included in the type series, it cannot be considered to be a type.
1♀ , Chinchilla, Qld. (not Westwood as recorded by Roberts). K60172
Thevenemyia longipalpis (Hardy) (Hall, 1969:43).

Superfamily EMPIDOIDEA
Family EMPIDIDAE

Asymphyloptera quadriseta Smith, 1960:245.
HT♂ , AT♀ , Katoomba, N.S.W. K68284-5

Microphorella iota Colless, 1964:320.
PT 2♀ , Springwood, N.S.W. K68439-40

Empis alata G. Hardy, 1934b:177.
ST ♂ , Blackheath, N.S.W. (Labelled "HT") K68572

Family DOLICHOPODIDAE

Paraliptus mirabilis Bezzi, 1923b:181.
HT ♀ , Southport, Qld. K48702

Division CYCLORRHAPHA
Series ASCHIZA
Superfamily PHOROIDEA
Family PLATYPEZIDAE

Platypeza denticulata Tonnoir, 1925a:309.
HT ♂ , Sydney, N.S.W. K48706

Platypeza fergusoni Tonnoir, 1925a:307.
HT ♂ , Hobart, Tas. K48707
PT ♀ , Sydney, N.S.W. K48708

Platypeza acuminata Tonnoir, 1925a:310.
HT ♂ , Sydney, N.S.W. K48709

Platypeza griseola Tonnoir, 1925a:309.
HT ♂ , Sydney, N.S.W. K48710

Superfamily SYRPHOIDEA
Family SYRPHIDAE
Subfamily MILESIINAE

Cerioides euphara Riek, 1954:107.
ST 1♂, 1♀ , Westwood, Qld. (Labelled "HT ♂ " and "PT ♀ "). K53603-4
ST ♀ , Gayndah, Qld. (Labelled "PT"). K52032
ST ♀ , Gayndah, Qld. (Labelled "PT"). K52034
Ceriana euphara (Riek) comb. nov.

Cerioides alboseta Ferguson, 1926a:145.
ST ♂ , Gordonvale, Qld. (Labelled "HT"). K53605
Ceriana alboseta (Ferguson) comb. nov.

Cerioides platypus Ferguson, 1926a:144.
HT ♂ , AT ♀ , South Australia K36977
Ceriana platypus (Ferguson) comb. nov.

Cerioides apicalis Ferguson, 1926a:147.
HT ♂ , Gayndah, Qld. K52033
Ceriana apicalis (Ferguson) comb. nov.

Cerioides mastersi Ferguson, 1926a:151.
HT ♀ , South Australia K52035
Ceriana mastersi (Ferguson) comb. nov.

Cerioides alaplicata G. Hardy, 1945:83.
ST 1♂, 1♀ , Goondiwindi, Qld. K70544
Ceriana alaplicata (Hardy) comb. nov.

Criorhina multicolor Ferguson, 1926b:523.
HT ♂ , Eccleston, N.S.W. K55146

Criorhina spadix G. Hardy, 1921:17.
HT ♂ , Hobart, Tas K70545

Subfamily MICRODONTINAE

Microdon waterhousei Ferguson, 1926a:174.
HT ♀ , Killara, N.S.W. K55145

Microdon dimorphon Ferguson, 1926a:177.
ST 1♂, 1♀ , Armadale, W.A. K55144
Both specimens are on a common pin labelled paratype. The ♂ has the head missing.

Microdon chalybeus Ferguson, 1926a:176.
HT ♂ , no data.
This specimen is represented by a damaged wing.

Subfamily SYRPHINAE

Chrysotoxum elongatum G. Hardy, 1921:13.
HT ♂ , Geeveston, Tas. K70546
AT ♀ , Hobart, Tas. K70547
Hardimyia elongata (Hardy) (Ferguson, 1926b:534).

Citrogramma notiale Vockeroth, 1969:95.
PT ♀ , Sydney, N.S.W.
This specimen has not been located in the collection.

Series SCHIZOPHORA
Superfamily TEPHRITOIDEA
Family PLATYSTOMATIDAE

Mesoctenia australis D. McAlpine, 1973:35.
HT ♂ , PT 2♂, 5♀ , Thornton Range to Daintree River ferry, Qld. K70162-9

Plagiostenopterina claudiana D. McAlpine, 1973:41.
HT ♂ , PT 10♂, 8♀ , Claudie River, near Mount Lamond, Qld. K70143-61

Plagiostenopterina crinita D. McAlpine, 1973:42.
PT ♂ , Mount Bartle Frere, Qld. K70548

Lamprogaster tricauda D. McAlpine, 1973:48.
HT ♂ , PT 7♂, 1♀ , Mary's Creek, near Gympie, Qld. K70170-5

Lamprogaster pseudelongata Malloch, 1930a:432.
PT ♀ , Cairns, Qld. K67932
This is a synonym of *Lamprogaster indistincta* Malloch (D. McAlpine, 1973:50).

Lamprogaster nigrihirta D. McAlpine, 1973:51.
HT ♂ , PT ♂ , Mulgrave River, 6km W of Gordonvale, Qld. K70176-7
PT ♂ , Thornton Range to Daintree River ferry, Qld. K70178
PT ♂ , Lake Barrine, Atherton Tableland, Qld. K70179

Lamprogaster flavihirta D. McAlpine, 1973:52.
PT 2♂, Herberton, Qld. K70180-1

Lamprogaster rugifacies D. McAlpine, 1973:52.
PT ♂ , Iron Range, Qld. K70182

Lamprogaster imperialis D. McAlpine, 1973:53.
HT ♂ , PT 27♂, 18♀ , Millstream Falls, near Ravenshoe, Qld. K70183-228
PT 1♂, 2♀ , Kuranda, Qld. K70229-33
PT ♀ , Almaden, near Chillagoe, Qld. K57663
PT ♀ , Cairns, Qld. K70234

Lamprogaster viola Malloch, 1929b:515.
PT ♂ , Herberton, Qld. K67933

Lamprogaster corax D. McAlpine, 1973:57.
PT ♀ , Coen River, Qld. K70238

Lamprogaster excelsa D. McAlpine, 1973:62.
HT ♂ , PT ♀ , Mount Kosciusko, N.S.W. K70236-7
PT ♀ , Buckenderra, near Adaminaby, N.S.W. K70238

Lamprogaster relucens D. McAlpine, 1973:65.
HT ♂ , Northmead, near Parramatta, N.S.W. K70239
PT ♂ , Royalla, near Queenbeyan, N.S.W. K70240
PT ♀ , Hay, N.S.W. K70241

Duomyia personata D. McAlpine, 1973:80.
PT ♂ , Black Mountain, A.C.T. K70058

Duomyia convallis D. McAlpine, 1973:80.
PT ♀ , Carnarvon Gorge, Qld. K70059

Duomyia pallipes D. McAlpine, 1973:82.
PT ♀ , Sydney, N.S.W. K70060
PT ♂ , Bondi sandhills, near Sydney, N.S.W. K70061

Duomyia monteithi D. McAlpine, 1973:84.
PT ♀ , Claudie River, near Mount Lamond, Qld. K70062

Duomyia foliata D. McAlpine, 1973:85.
PT ♂ , Red Island Point, near Cape York, Qld. K70063

Duomyia eremia D. McAlpine, 1973:89
PT ♂ , 77km WSW of Alice Springs, N.T. K70064

Duomyia smaragdina D. McAlpine, 1973:89.
PT ♀ , Cocoa Beach, Trimouille Island, W.A. K70065

Duomyia lacunosa D. McAlpine, 1973:90.
PT 2♂, 1♀ , Nedlands, near Perth, W.A. K70066-8
PT ♂ , Wyperfield National Park, Vic. K70069

Duomyia marginalis D. McAlpine, 1973:91.
PT ♀ , Bannyabba, c. 64km N of Grafton, N.S.W. K70070

Duomyia chaetostigma D. McAlpine, 1973:92.
HT ♂ , "Wheogo", 19km NE of Dunedoo, N.S.W. K70071

Duomyia curta D. McAlpine, 1973:97.
HT ♂ , PT 2♂, 9♀ , Iluka, Clarence River, N.S.W. K70072-81

Duomyia octoseta D. McAlpine, 1973:98.
HT ♂ , PT 3♂, 4♀ , Iluka, Clarence River, N.S.W. K70082-9

Duomyia capnodes D. McAlpine, 1973:103.
PT ♂ , Cape Naturaliste, W.A. K70090
PT ♀ , 6km W of Margaret River, W.A. K70091

Duomyia ustulata D. McAlpine, 1973:104.
PT 1♂, 1♀ , 8km N of Nannup, W.A. K70092-3

Duomyia brevicornis D. McAlpine, 1973:105.
HT ♀ , Flat Rock Crossing, Royal National Park, N.S.W. K70094

Duomyia capitalis D. McAlpine, 1973:108.
PT 3♂, 1♀ , Black Mountain, A.C.T. K70095-8

Duomyia picta D. McAlpine, 1973:108.
HT ♂ , PT ♂ , Iluka, Clarence River, N.S.W. K70099-100

Duomyia rasa D. McAlpine, 1973:109.
HT♀ , Kuranda, Qld. K70101

Duomyia latipilus D. McAlpine, 1973:110.
HT♂ , PT♂ , Iluka, Clarence River, N.S.W. K70102-3

Duomyia parallela D. McAlpine, 1973:111.
PT♂ , Dongara, W.A. K70104

Duomyia adelaidae D. McAlpine, 1973:112.
PT♂ , National Park, S.A. K70105

Duomyia iris D. McAlpine, 1973:113.
HT♂ , PT 2♀ , Bunbury, W.A. K70106-8
PT 2♀ , Capel district, 29km S of Bunbury, W.A. K70109-10

Duomyia acrogenea D. McAlpine, 1973:113.
PT♂ , 38km W of Moora, W.A. K70111

Duomyia uptoni D. McAlpine, 1973:114.
PT♂ , 30km W of Watheroo, W.A. K70112

Duomyia viridaurea D. McAlpine, 1973:115.
PT♂ , 66km E of Esperance, W.A. K70113

Duomyia scintilla D. McAlpine, 1973:118.
PT♀ , National Park, N.S.W. K70114
PT 1♂, 1♀ , Halfway Creek, 29km S of Grafton, N.S.W. K70115-6

Duomyia hypene D. McAlpine, 1973:121.
HT♂ , PT 6♂, 8♀ , Goonoo State Forest, 8km S of Mendooran, N.S.W. . K70117-30

Duomyia loxocerina D. McAlpine, 1973:127.
HT♂ , McCarr's Creek, Ku-ring-gai Chase, near Sydney, N.S.W. K70132
PT ♀ , West Head, Ku-Ring-gai Chase, N.S.W. K70133
PT 1♂, 1♀ , Towler's Bay, Pittwater, near Sydney, N.S.W. K70134

Duomyia cancellata D. McAlpine, 1973:128.
HT♂ , PT♂ , Iluka, Clarence River, N.S.W. K70135-6
PT 2♂, Shoal Bay, near Port Stephens, N.S.W. K70137-8

Duomyia hebes D. McAlpine, 1973:129.
PT 1♂, 1♀ , Shute Harbour, near Proserpine, Qld. K70139-40

Duomyia brevifurca D. McAlpine, 1973:131.
PT♂ , Mingela, Charters Towers district, Qld. K70141

Duomyia rudis D. McAlpine, 1973:131.
PT♀ , Burnett River, Eidsvold, Qld. K70142

Euprosopia rete D. McAlpine, 1973:140.
HT♂ , Kuranda, Qld.
PT 2♂, 2♀, Mulgrave River, 6km W of Gordonvale, Qld. K69577-80

Euprosopia acula D. McAlpine, 1973:142.
HT♂ , PT♂ , Barron River, The Crater, near Herberton, Qld. K69581-2

Euprosopia xanthops D. McAlpine, 1973:144.
HT♂ , 3km E of Cardstone, Tully River, Qld. K69583
PT ♂, Mulgrave River, 6km W of Gordonvale, Qld. K69584
PT 5♀ , 3km N of Tully River bridge, E of Cardstone, Qld. K69585-91

Euprosopia lenticula D. McAlpine, 1973:146.
PT♂ , Palm Island, near Ingham, Qld. K69592

Euprosopia sericata D. McAlpine, 1973:146.
HT♀ , 3km NW of Mount Mowbullan, Bunya Mountains, Qld. K69593
PT♂ , Mary's Creek, near Gympie, Qld. K69594
PT 9♂, 3♀ , 3-4km NW of Mount Mowbullan, Bunya Mountains, Qld. K69595-606

Euprosopia crassa C. McAlpine, 1973:148.
PT 1♂, 1♀ , Nerang River, near Springbrook Forest, 21km S of Nerang, Qld. K69608-9

Euprosopia piperata D. McAlpine, 1973:150.
HT♂ , PT 3♂, 13♀ , Upper Allyn, near Eccleston, N.S.W. K69610-26

Euprosopia conferta D. McAlpine, 1973:151.
HT♀ , PT 5♂, 10♀ , Birthday Creek Falls, near Paluma, Qld. K69627-42
PT♀ , Birthday Creek, near Paluma, Qld K69643
PT 1♂, 2♀ , 3km W of Paluma, Qld. K69644-6
PT 6♂, 14♀ , Paluma, Qld. K69647-66

Euprosopia integra D. McAlpine, 1973:153.
HT♀ , PT 3♂, The Crater, near Herberton, Qld. K69667-70
PT♂ , Atherton, Qld. K69671

Euprosopia kurandae D. McAlpine, 1973:154.
HT♀ , PT 4♂, Kuranda, Qld. K69672-6

Euprosopia mica D. McAlpine, 1973:156.
HT♀ , PT♀ , The Crater, near Herberton, Qld. K69677-8

Euprosopia remota D. McAlpine, 1973:156.
HT♂ , PT 7♀ , Tucker's Rock, near Repton, N.S.W. K69679-86
PT♀ , Shoal Bay, near Port Stephens, N.S.W. K69687

Euprosopia hollowayi D. McAlpine, 1973:158.
HT♂ , PT 2♂, 2♀, 3km NW of Mount Mowbullan, Bunya Mountains, Qld. K69688-92
PT♂ , 5km NW of Mount Mowbullan, Bunya Mountains, Qld. K69693

Euprosopia megastigma D. McAlpine, 1973:159.
HT♂ , PT 19♂, 6♀ , Otford, N.S.W. K69694-719
PT 6♂, 20♀ , Upper Allyn, near Eccleston, N.S.W. K69720-45
PT♂ , Roseville, near Sydney, N.S.W. K69746

Euprosopia crispa D. McAlpine, 1973:160.
HT♂ , PT 2♂, 2♀ , Newport, near Sydney, N.S.W. K69747-51
PT♀ , West Head, Ku-ring-gai Chase, N.S.W. K69752
PT♂ , Katoomba, N.S.W. K69753
PT 1♂, 1♀ , Ku-ring-gai Chase, N.S.W. K70245-6

Euprosopia albipila D. McAlpine, 1973:161.
HT♂ , PT 4♂, 2♀ , Katoomba, N.S.W. K69754-60
PT♂ , Rennix Gap, Snowy Mountains, N.S.W. K70549
PT♀ , Perisher Valley, Snowy Mountains, N.S.W. K70550

Euprosopia vitrea D. McAlpine, 1973:165.
HT♂ , PT 6♂, 21♀ , Mount Boyce, N.S.W. K69761-88
PT 6♂, 3♀ , 3km W of Katoomba, N.S.W. K69789-97
PT 2♂, 1♀ , Katoomba, N.S.W. K69798-800
PT 1♂, 1♀ , Boyd River, N.S.W. K69801-2

Euprosopia alpina D. McAlpine, 1973:167.
PT 5♀, Moonbar, N.S.W. K69803-7
PT♀, Wilson's Valley, N.S.W. K69808
PT♂, Lee's Springs, Brindabella Range, A.C.T. K70551
The A.C.T. specimen has not been located in the collection.

Euprosopia celsa D. McAlpine, 1973:168.
HT♂, PT 1♂, 2♀, Point Lookout, New England National Park, near Ebor, N.S.W. K69809-12

Euprosopia hypostigma D. McAlpine, 1973:168.
HT♀, PT♀, Upper Allyn, near Eccleston, N.S.W. K69813-4

Euprosopia subacuta D. McAlpine, 1973:169.
PT♀, Picnic Rock, Lamington National Park, Qld. K69815

Euprosopia filicornis D. McAlpine, 1973:170.
HT♂, PT 8♂, 5♀, Kurnell, N.S.W. K69816-29
PT♀, Bronte, N.S.W. K69830
PT♀, Centennial Park, near Sydney, N.S.W. K69831
PT♀, Shoal Bay, near Port Stephens, N.S.W. K69832
PT 2♂, 2♀, Coogee, N.S.W. K47949

Euprosopia ramosa D. McAlpine, 1973:172.
HT♀, The Crater, near Herberton, Qld. K69833

Euprosopia subula D. McAlpine, 1973:174.
HT♀, PT 10♂, 14♀, Royal National Park, N.S.W. K69834-58
PT 4♂, 6♀, Otford, N.S.W. K69859-68
PT♂, Ourimbah, near Gosford, N.S.W. K70553
PT♀, Nepean River, N.S.W. K70554

Euprosopia armipes D. McAlpine, 1973:177.
HT♀, PT 21♂, 26♀, Iluka, Clarence River, N.S.W. K69869-916
PT♂, Brisbane, Qld. K69917

Euprosopia monodon D. McAlpine, 1973:178.
HT♂, PT 1♂, 1♀, Tully River, 3km E of Cardstone, Qld. K69918-20

Euprosopia comes D. McAlpine, 1973:181.
HT♂, PT♂, Mulgrave River, 6km W of Gordonvale, Qld. K69921-2
PT♀, Claudie River, near Mount Lamond, Qld. K69923
PT♂, Townsville, Qld. K69924

Euprosopia inermis D. McAlpine, 1973:183.
HT♀, Daintree River, 10km NW of Daintree, Qld. K69925

Family PYRGOTIDAE

Pyrgella carnei Paramonov, 1958:117.
PT♂, Little Desert, 8km S of Kiata, Vic. K70557

Austromyia neglecta D. Hardy, 1954:328.
HT♀, AT♂, PT♂, Tuross, N.S.W. K70555-6
Neotoxura neglecta (Hardy) (Paramonov, 1958:114).

Musgravena anthonyi Paramonov, 1958:117.
HT♀, Little Desert, 14km S of Kiata, Vic. K67918
According to Steyskal (1965:447) this species is a synonym of *Musgravena nova* (Walker).

Family TEPHRITIDAE
Subfamily DACINAE

Callantra pusilla May, 1965:58.
PT 2♂, Kuranda, Qld. K68422-3

Dacus visendus D. Hardy, 1951:135.
PT 2♂, 2♀, Babinda, Qld. K67713

Dacus breviaculeus D. Hardy, 1951:145.
PT♂, Cairns, Qld. K67716
PT♀, Atherton Tableland, Qld. K67716

Dacus kraussi D. Hardy, 1951:156.
PT 4♂, 1♀, Deeral, Qld. K67714
PT 3♂, 2♀, Atherton, Qld. K67715

Dacus laticaudus D. Hardy, 1950:87.
PT 6♂, 3♀, Deeral, Qld. K70558-9

Strumeta aquilonis May, 1965:62.
PT 2♂, Nightcliff, N.T. K68424-5
Dacus aquilonis (May) comb. nov.

Strumeta tenuifascia May, 1965:64.
PT 2♂, Berrimah, N.T. K68426-7
Dacus tenuifascia (May) comb. nov.

Dacus algaiae D. Hardy, 1951:132.
PT♂, Atherton Tableland, Qld. K67712

Subfamily TRYPETINAE

Ceratitella bifasciata D. Hardy, 1967:133.
PT♂, Ravensbourne, Qld. K70552

Ceratitella unifasciata D. Hardy, 1967:137.
PT♀, Cairns, Qld. K70560

Hendelina australina D. Hardy, 1951:180.
PT 1♂, 1♀, Hartley's Creek, Qld. K67711
Myoleja australina (Hardy) comb. nov.

Rioxa confusa D. Hardy, 1951:183.
PT 1♂, 2♀, Julatten, Qld. K67721
PT 4♂, Atherton, Qld. K67721
Dirioxa confusa (Hardy) comb. nov.

Superfamily MICROPEZOIDEA
Family CYPSELOSOMATIDAE

Cypselosoma australis D. McAlpine, 1966:676.
HT♂, PT 63♂, 39♀, Bat cave, Carrai, via Kempsey, N.S.W. K70562-4

Superfamily HELEOMYZOIDEA
Family HELEOMYZIDAE

Tapeigaster marginifrons Bezzi, 1923:74.
ST♂, Blue Mountains, N.S.W. (Labelled "Type ♂") K47510
ST♀, Sydney, N.S.W. (Labelled "Type ♀") K47510

Tapeigaster argyrospila Bezzi, 1923:77.
HT♂, Blue Mountains, N.S.W. K47512

Tapeigaster luteipennis Bezzi, 1923:76.
HT♂, Eccleston, N.S.W. K47511

Leriopsis montana D. McAlpine, 1967:76.
HT♀, PT 10♂, 8♀, Lake Wilks to Lake Dove, Cradle Mountain, Tas. K68786-92
PT 3♂, 6♀, Hanson's Peak to Cradle Mountain, Tas. K68793-5

PT♂ , Waldheim, Cradle Mountain, Tas. K68797
PT♂ , 26km NE of Cradle Mountain, Tas. K68796
PT♂ , Mount Barrow, near Launceston, Tas. K68798
PT♂ , Franklin River crossing, Lyell Highway, Tas. K68799
PT 1♂, 2♀ , Lake Esperance, Hartz Mountains, Tas. K68800

Trixoleria maculata D. McAlpine, 1967:78.
HT♂ , Mount York, Blue Mountains, N.S.W. K68801
PT 4♂, 2♀, Mount Boyce, Blue Mountains, N.S.W. K68803-7
PT♂ , Wentworth Falls, Blue Mountains, N.S.W. K68802
PT♀ , Burke's Creek, near The Rock, N.S.W. K68808

Austroleria extensa D. McAlpine, 1967:80.
HT♂ , PT 47♂, 56♀ , Mount Wilson, Blue Mountains, N.S.W. K68809-42
PT♀ , Mount York, Blue Mountains, N.S.W. K68843
PT 2♂, below Govett's Leap, Blue Mountains, N.S.W. K68844
PT♀ , Katoomba, N.S.W. K68846
PT 2♂, 2♀ , Wentworth Falls, N.S.W. K68847-50
PT♂ , Kurrajong, near Richmond, N.S.W. K68845
PT 3♂, 2♀ , Tubrabucca, Upper Hunter district, N.S.W. K68854-5
PT 2♂, 1♀ , Otford, Illawarra district, N.S.W. K68851-2
PT 2♀ , Clyde Mountain, near Braidwood, N.S.W. K68853

Austroleria truncata D. McAlpine, 1967:81.
HT♂ , PT 49♂, 59♀ , Mount Wilson, Blue Mountains, N.S.W. K68954-91
PT♂ , below Govett's Leap, Blue Mountains, N.S.W. K68993
PT♀ , Wentworth Falls, N.S.W. K68992
PT♀ , Kurrajong, near Richmond, N.S.W. K68994

Diplogeomyza incisa D. McAlpine, 1967:85.
HT♂ , Fernshaw, 10km E of Healesville, Vic. K68856

Diplogeomyza wirthi D. McAlpine, 1967:86.
HT♂ , Colo Vale, near Mittagong, N.S.W. K68857
PT 8♂, Clyde Mountain, near Braidwood, N.S.W. K68858-9
PT♂ , Mount York, Blue Mountains, N.S.W. K68860
PT 7♂, 4♀ , Mount Wilson, Blue Mountains, N.S.W. K68861-3

Diplogeomyza conformis D. McAlpine, 1967:88.
PT♂ , Clyde Mountain, near Braidwood, N.S.W. K68867
PT 3♂, 5♀ , Black Mountain, Canberra, A.C.T. K68864-6
PT 1♂, 1♀ , Paddy's River, near Marulan, N.S.W. K68868

Diplogeomyza immaculata D. McAlpine, 1967:89.
HT♀ , PT 5♂, 8♀ , Barron River, The Crater, Herberton, Qld. K68869-75

Diplogeomyza hardyi hardyi D. McAlpine, 1967:90.
HT♂ , PT 2♂, 14♀ , Katoomba, N.S.W. K68876-94
PT 41♂, 35♀ , Mount Wilson, Blue Mountains, N.S.W. K68895-914

Diplogeomyza hardyi tasmanica D. McAlpine, 1967:92.
HT♂ , PT 3♂, 4♀ , Anne River, near Geeveston, Tas. K68915-7
PT♀ , Hartz Mountains, Tas. K68931
PT 3♂, 4♀ , Ferntree, near Hobart, Tas. K68929-30
PT♂ , near Russell Falls, Mount Field National Park, Tas. K68927
PT 3♂, Eaglehawk Neck, Tas. K68928
PT 2♂, Lake Saint Clair, Tas. K68926
PT♀ , Renison Bell, Tas. K68925
PT 2♂, 1♀ , Pieman River, near Roseberry, Tas. K68923-4

PT♀ , Waldheim, near Cradle Mountain, Tas. K68922
PT 1♂, 1♀ , Marakoopa Caves, near Mole Creek, Tas. K68919-20
PT ♂ , Western Tiers, Lake Highway, Tas. K68921
PT♀ , Mount Barrow, near Launceston, Tas. K68918

Diplogeomyza flavipalpis D. McAlpine, 1967:93.
HT♂ , PT♀ , Mount Boyce, near Blackheath, N.S.W. K69044-5
PT♀ , Mount Wilson, Blue Mountains, N.S.W. K69046

Diplogeomyza tridens D. McAlpine, 1967:94.
HT♂ , PT 4♂, 4♀ , Binna Burra, Lamington National Park, Qld. K69003-6
PT 11♂, 14♀ , Tamborine Mountain, Qld. K69014-20
PT 2♂, Mount Glorious, near Brisbane, Qld. K69013
PT 8♂, 12♀ , Summer Creek, near Kennilworth, Qld. K69008-12
PT♀ , Mapleton, Qld. K69007
PT♀ , Huonbrook, near Mullumbimby, N.S.W. K69021
PT♂ , Bruxner Park, near Coff's Harbour, N.S.W. K69022
PT 4♀ , Dorrigo National Park, N.S.W. K69023-4

Diplogeomyza victoriae D. McAlpine, 1967:96.
HT♂ , PT♂ , Mount Donna Buang, near Warburton, Vic. K69025-6
PT 5♂, 6♀ , Cement Creek, near Warburton, Vic. K69027-31
PT 2♀ , Warburton, Vic. K69032
PT♀ , Ferntree Gully, Vic. K69033
PT♂ , 21km W of Matlock, Vic. K69034
PT♂ , Frenchman's Gap, near Wood's Point, Vic K69035

Diplogeomyza annularis D. McAlpine, 1967:96.
HT♂ , PT 3♂, 2♀ , Royal National Park, N.S.W. K69036-41
PT 1♂, 1♀ , Otford, N.S.W. K69042-3

Diplogeomyza spinosa D. McAlpine, 1967:98.
HT♂ , PT 19♂, 32♀ , Royal National Park, N.S.W. K69047-69
PT 10♂, Otford, N.S.W. K69070-5
PT 10♂, 6♀ , Minnamurra Falls, near Kiama, N.S.W. K69076-83
PT♂ , Clyde Mountain, near Braidwood, N.S.W. K69084
PT♀ , Springwood, N.S.W. K69098
PT 4♂, 3♀ , Wentworth Falls, N.S.W. K69095-7
PT♀ , below Govett's Leap, Blue Mountains, N.S.W. K69094
PT 6♂, 3♀ , Mount Wilson, Blue Mountains, N.S.W. K69087-93
PT♀ , near Mangrove Mountain, Hawkesbury River, N.S.W. K69085
PT♂ , Mooney Mooney Creek, near Gosford, N.S.W. K69086

Diplogeomyza signata D. McAlpine, 1967:99.
HT♂ , PT 2♂, 3♀ , Wentworth Falls, N.S.W. K69099-102
PT♂ , below Govett's Leap, Blue Mountains, N.S.W. K69105
PT♀ , Mount Wilson, Blue Mountains, N.S.W. K69104
PT♂ , Mooney Mooney Creek, near Gosford, N.S.W. K69103
PT 10♂, 7♀ , Royal National Park, N.S.W. K69106-22
PT 1♂, 1♀ , Otford, N.S.W. K69123-4
PT 1♂, 4♀ , Minnamurra Falls, near Kiama, N.S.W. K69126-30

Diplogeomyza media D. McAlpine, 1967:100.
HT♂ , PT 7♂, 7♀ , Mount Wilson, Blue Mountains, N.S.W. K69132-44
PT♀ , Mount York, Blue Mountains, N.S.W. K69145
PT♂ , Wentworth Falls, N.S.W. K69146
PT♀ , Gowee Gulch, near Rylstone, N.S.W. K69151

PT 2♂, 1♀, Royal National Park, N.S.W. K69147-9
PT 3♂, Clyde Mountain, near Braidwood, N.S.W. K69150

Diplogeomyza pectinervis D. McAlpine, 1967:104.
HT♂, PT 1♂, 2♀, Kurrajong, N.S.W. K69152-5
PT♀, Mount Wilson, Blue Mountains, N.S.W. K69172
PT♀, Wollombi, near Cessnock, N.S.W. K69169
PT 3♀, Mooney Mooney Creek, near Gosford, N.S.W. K69170
PT 4♂, 9♀, Royal National Park, N.S.W. K69156-67
PT♀, Palm Grove, near Wyong, N.S.W. K69171
PT♂, Colo Vale, near Mittagong, N.S.W. K69168

Cairnsimyia sydneiensis D. McAlpine, 1968:270.
PT♀, Sydney, N.S.W. K69173

Cairnsimyia excavata D. McAlpine, 1968:271.
PT 1♂, 1♀, Stanthorpe, Qld. K69174-5

Cairnsimyia uniseta D. McAlpine, 1968:272.
HT♂, Kurrajong, N.S.W. K69176

Cairnsimyia cavifrons Malloch, 1931:294.
PT♂, Cairns, Qld. K68580

Family SPHAEROCERIDAE

Leptocera papuana Richards, 1973:308.
PT♂, Lake Placid, near Cairns, Qld. K70407

Leptocera territorialis Richards, 1973:313.
PT♀, Kuranda, Qld. K70428
PT 2♀, near head of Clohesy River, Atherton Tableland, Qld. K70429

Leptocera peculiaris Richards, 1973:324.
PT 2♂, 7♀, Kurnell, N.S.W. K70430-2

Leptocera fucicola Richards, 1973:326.
HT♂, Long Reef, near Sydney, N.S.W. K70433
PT 1♂, 1♀, Careel Bay, near Avalon, N.S.W. K70434
Both paratypes are slightly damaged.

Leptocera subsinuata Richards, 1973:331.
PT♂, Otford, N.S.W. K70440
PT♂, Northmead, N.S.W. K70441
PT 1♂, 1♀, Royal National Park, N.S.W. K70442-3
PT♂, Mount Wilson, Blue Mountains, N.S.W. K70444
PT♀, Kuranda, Qld. K70439
PT♀, Broken River, Eungella, Qld. K70438

Leptocera dorrigonis Richards, 1973:333.
HT♂, Dorrigo National Park, N.S.W. K70435
PT♂, Royal National Park, N.S.W. K70436
PT♀, Otford, N.S.W. K70437
PT♂, Mount Glorious, near Brisbane, Qld. K70491
The Queensland specimen is represented by a wing mounted on a slide.

Leptocera nitidipleura Richards, 1973:336.
HT♂, PT 3♂, 3♀, Royal National Park, N.S.W. K70445-51
PT 2♂, Mount Wilson, Blue Mountains, N.S.W. K70457-8
PT♀, Minnamurra Falls, near Kiama, N.S.W. K70459
PT♀, Mooney Mooney Creek, near Gosford, N.S.W. K70460

Leptocera fuscalis Richards, 1973:338.
HT♀ , PT♀ , Katoomba, N.S.W. K70461-2
The paratype has the head missing.

Leptocera trivittata Richards, 1973:340.
HT♂ , Otford, N.S.W. K70463
PT♀ , below Govett's Leap, Blue Mountains, N.S.W. K70464
PT♀ , Katoomba, N.S.W. K70465
PT♂ , Binna Burra, Lamington National Park, Qld. K70466

Leptocera percostata Richards, 1973:342.
PT♀ , Clyde Mountain, near Braidwood, N.S.W. K70467

Leptocera wilsoni Richards, 1973:343.
HT♀ , PT 1♂, 1♀ , Mount Wilson, Blue Mountains, N.S.W. K70468-70
The ♂ paratype is represented by a wing and two legs.

Leptocera capitalis Richards, 1973:343.
PT 3♀ , Burke's Creek, near The Rock, N.S.W. K70471
One specimen has the head missing.

Leptocera wentworthi Richards, 1973:355.
HT♂ , Wentworth Falls, Blue Mountains, N.S.W. K70475

Leptocera hardyina Richards, 1973:347.
HT♂ , PT♀ , Mount Wilson, Blue Mountains, N.S.W. K70472-3
PT♀ , Katoomba, N.S.W. K70474

Leptocera kurandensis Richards, 1973:358.
HT♀ , PT 4♀ , Kuranda, Qld. K70477-9

Leptocera cercalis Richards, 1973:362.
HT♀ , Otford, N.S.W. K70481

Leptocera aestivalis Richards, 1973:368.
PT♂ , Otford, N.S.W. K70482
PT 2♂, Huonbrook, near Mullumbimby, N.S.W. K70483
PT♂ , Springwood, N.S.W. K70484

Leptocera popularis Richards, 1973:378.
HT♂ , PT 3♀ , Royal National Park, N.S.W. K70488-9

Leptocera fenestrata Richards, 1973:379.
HT♀ , Binna Burra, Lamington National Park, Qld. K70486
PT♂ , Otford, N.S.W. K70487

Superfamily OPOMYZOIDEA
Family LONCHAEIDAE

Dasiops spathistilus J. McAlpine, 1964:672.
HT♀ , AT♂ , PT♀ , Dee Why Lagoon, near Sydney, N.S.W. K68351-3

Dasiops ruidifrons J. McAlpine, 1964:678.
HT♀ , Katoomba, N.S.W. K68354
PT ♀ , Kuranda, Qld. K68355

Dasiops phrikosifrons J. McAlpine, 1964:678.
HT♂ , AT♀ , PT 16♂, Bronte, near Sydney, N.S.W. K68356-73

Lamprolonchaea fulgida J. McAlpine, 1964:695.
PT♂ , 29km S of Bunbury, Capel district, W.A. K68374

Silba adelosa J. McAlpine, 1964a:701.
PT♂ , Otford, N.S.W. K68375

Silba vanemdeni J. McAlpine, 1975:998.
PT 1♂, 1♀, Claudie River, near Mount Lamond, Qld. K70688

Silba ramuscula J. McAlpine, 1964a:710.
HT♂, Mulgrave River, 6km W of Gordonvale, Qld. K68381

Silba horridomedea J. McAlpine, 1964a:711.
HT♂, AT♀, PT♂, Daintree River, Qld. K68382-4

Silba zopherosa J. McAlpine, 1964a:704.
HT♂, PT 4♂, Lake Placid, near Cairns, Qld. K68376-80
This species is a synonym of *Lonchaea obscuripennis* de Meijere (J. McAlpine, 1975:996).

Lonchaea choreoides Bezzi, 1923c:184.
ST 1♂, 1♀, Sydney, N.S.W. K48705

Lonchaea cuneifrons J. McAlpine, 1964a:748.
HT♂, Lake Placid, near Cairns, Qld. K68502
AT♀, Canal Creek, near Russel River, Qld. K68503

Family CLUSIIDAE

Tetrameringia ustulata D. McAlpine, 1960:69.
HT♂, PT♀, Sassafras Gully, Springwood, N.S.W. K67954-5
PT 2♂, 2♀, Wentworth Falls, N.S.W. K67956-8
PT♂, Royal National Park, N.S.W. K67959
PT 4♂, 9♀, Otford, N.S.W. K67960-4

Tetrameringia pubescens D. McAlpine, 1960:70.
HT♂, Mount Wilson, Blue Mountains, N.S.W. K67965

Heteromeringia pulla D. McAlpine, 1960:73.
HT♂, PT 8♂, 1♀, Royal National Park, N.S.W. K67966-70
PT♀, Otford, N.S.W. K67971

Heteromeringia spinulosa D. McAlpine, 1960:74.
HT♂, below Govett's Leap, Blue Mountains, N.S.W. K67972
PT♂, Otford, N.S.W. K67973

Heteromeringia norrisi D. McAlpine, 1960:74.
PT 1♂, 1♀, Applecross, near Perth, W.A. K67974-5

Heteromeringia hardyi D. McAlpine, 1960:75.
HT♂, PT 2♂, 7♀, Katoomba, N.S.W. K67976-85

Heteromeringia laticornis D. McAlpine, 1960:76.
HT♂, Royal National Park, N.S.W. K67986
PT♂, Otford, N.S.W. K67987

Czernyola australis D. McAlpine, 1960:78.
PT♀, Katoomba, N.S.W. K67988
Craspedochaeta australis (McAlpine) comb. nov.

Czernyola bisignata D. McAlpine, 1960:78.
HT♂, PT♀, Kuranda, Qld. K67989-90
Craspedochaeta bisignata (McAlpine) comb. nov.

Czernyola delta D. McAlpine, 1960:79.
HT♂, PT 2♂, 2♀, Lake Placid, near Cairns, Qld. K67991-4
PT♂, Kuranda, Qld. K67995
Craspedochaeta delta (McAlpine) comb. nov.

Clusiodes gladiator D. McAlpine, 1960:81.
HT ♂, PT ♀, Royal National Park, N.S.W. K67999-8000
PT 3♂, 1♀, Otford, N.S.W. K68001-3
PT 4♂, 3♀, Wentworth Falls, N.S.W. K68004-7
PT 4♂, below Govett's Leap, Blue Mountains, N.S.W. K68008-10
PT 3♂, 1♀, Mount Wilson, Blue Mountains, N.S.W. K68011-3
PT ♂, Barron River, near The Crater, Atherton Tableland, Qld. K68014

Clusiodes arguta D. McAlpine, 1960:82.
HT ♂, PT 4♀, Wentworth Falls, N.S.W. K67996-8

Clusiodes megaspilos D. McAlpine, 1960:83.
HT ♂, PT 3♂, 5♀, Wentworth Falls, N.S.W. K68015-20
PT ♂, Mount Wilson, Blue Mountains, N.S.W. K68021

Clusiodes clara D. McAlpine, 1960:83.
HT ♀, Silkwood, near Innisfail, Qld. K68022

Parahendelia latifrons D. McAlpine, 1960:84.
HT ♂, PT ♀, Wentworth Falls, N.S.W. K68023-4
PT 3♂, Mount Wilson, Blue Mountains, N.S.W. K68025-7

Parahendelia nigriceps D. McAlpine, 1960:85.
HT ♂, Mount Wilson, Blue Mountains, N.S.W. K68028

Allometopon striatum D. McAlpine, 1960:87.
HT ♀, Kuranda, Qld. K68029

Family AGROMYZIDAE

Agromyza testacea Spencer, 1963:308.
HT ♀, Kuranda, Qld. K68596

Japanagromyza eucalypti Spencer, 1963:309.
HT ♂, Lisarow, N.S.W. K68597

Melanagromyza apii Hering, 1951:736.
PT ♀, Mona Vale, N.S.W. K70561
PT 2♂, 1♀, Mascot, N.S.W. K70565

Melanagromyza cassiae Spencer, 1963:314.
PT ♀, Careel Bay, near Avalon, N.S.W. K68598

Melanagromyza placida Spencer, 1963:319.
HT ♂, Lake Placid, near Cairns, Qld. K68599

Melanagromyza seneciophila Spencer, 1963:319.
PT ♀, Waterfall, Royal National Park, N.S.W. K68600

Ophiomyia solanicola Spencer, 1963:324.
PT ♀, Clyde Mountain, near Braidwood, N.S.W. K68620

Phytobia caliginosa Spencer, 1963:327.
HT ♀, Sassafras Gully, Springwood, N.S.W. K68601
Amauromyza caliginosa (Spencer) (Spencer, in press).

Phytobia poemyzina Spencer, 1963:328.
HT ♂, PT ♀, Otford, N.S.W. K68602
PT ♂, Katoomba, N.S.W. K68603
PT ♀, Mount Wilson, Blue Mountains, N.S.W. K68604
Cerodontha poemyzina (Spencer) (Spencer, in press).

Phytobia triplicata Spencer, 1963:328.
HT ♀, PT 3♂, Pacific Highway, south side of Hawkesbury River, N.S.W. K70566
PT ♂, Wentworth Falls, N.S.W. K70567

PT 1♂, 1♀, Royal National Park, N.S.W. K70568
PT 2♂, Hartley, N.S.W. K70569
PT 1♂, 3♀, Bargo, N.S.W. K70570
Cerodontha triplicata (Spencer) (Spencer, in press).

Liriomyza australina Spencer, 1963:331.
HT♀, Sassafras Gully, near Springwood, N.S.W. K68605
PT♂, Otford, N.S.W. K68606

Liriomyza helichrysi Spencer, 1963:333.
PT♂, Mount Gibraltar, near Bowral, N.S.W. K68607

Liriomyza obscurata Spencer, 1963:334.
HT♂, Tubrabucca to Moonan, Upper Hunter district, N.S.W. K68608
PT♂, Mount Wilson, Blue Mountains, N.S.W. K68612
PT 1♂, 1♀, Belltrees, near Scone, N.S.W. K68613
PT 2♀, Bronte, near Sydney, N.S.W. K68609
PT♀, Mount Tomah, Blue Mountains, N.S.W. K68610
PT♀, Lawson, Blue Mountains, N.S.W. K68611

Phytoliriomyza australensis Spencer, 1963:335.
HT♂, Royal National Park, N.S.W. K68614
PT 2♀, Sassafras Gully, Springwood, N.S.W. K68617
PT 2♂, Jenolan camping ground, Blue Mountains, N.S.W. K68615
PT♂, head of Clohesy River, Atherton Tableland, Qld. K68618
PT 2♂, Lawson, Blue Mountains, N.S.W. K68616
The Queensland specimen has not been located in the collection.

Phytobia pittosporocaulis Hering, 1962:84.
PT 2♂, 1♀, Normanhurst, near Sydney, N.S.W. K70571
PT 2♀, Sydney, N.S.W. K70572
Phytoliriomyza pittosporocaulis (Hering) (Spencer, in press).

Phytobia pittosporophylli Hering, 1962:89.
PT 8♂, 4♀, Roseville, near Sydney, N.S.W. K68624
Phytoliriomyza pittosporophylli (Hering) (Spencer, in press).

Phytomyza clematidicolla Spencer, 1963:337.
PT♂, Sassafras Gully, near Springwood, N.S.W. K68619

Superfamily ASTEIOIDEA
Family ASTEIIDAE

Leiomyza nitidula Malloch, 1924c:338.
HT♀, Sydney, N.S.W. K70573

Superfamily DROSOPHILOIDEA
Family DROSOPHILIDAE

Drosophila versicolor Mather, 1955:573.
ST 3♂, 3♀, Moggill, near Brisbane, Qld. K67825-30
Specimens are labelled "HT♂", "AT♀" and PT.
This is a synonym of *Drosophila buzzatii* Paterson and Wheeler (Mather, 1957:224).

Drosophila setifemur Malloch, 1924d:351.
HT♀, Sydney, N.S.W. K50090
This species is a synonym of *Drosophila sulfurigaster* (Duda) (Wilson, *et al.*, 1969:211).

Drosophila serrata birchii Dobzhansky and Mather, 1961:464.
ST 1♂, 1♀, Crystal Cascades, near Cairns, Qld. K70574-5
Labelled HT and AT.
Drosophila birchii Dobzhansky and Mather (Ayala, 1965:538).

Drosophila smithersi Bock, 1976:17.
HT ♂, Mulgrave River, 6km W of Gordonvale, Qld. K70576

Drosophila dispar Mather, 1955:570.
ST 3♂, 3♀, Samford, Qld. K67819-24
Labelled HT ♂, AT ♀, and PT.

Drosophila pinnitarsus Bock, 1976:21.
HT ♂, PT 1♂, 1♀, Huonbrook, near Mullumbimby, N.S.W. K70577-8

Drosophila progastor Bock, 1976:24.
HT ♂, Birthday Creek, 11km W of Paluma, Qld. K70579

Drosophila polypori Malloch, 1924d:351.
HT ♀, Ourimbah, N.S.W. K50088
This specimen is damaged, having the abdomen and a wing missing.

Drosophila mycetophaga Malloch, 1924d:351.
HT ♂, Ourimbah, N.S.W. K50089

Drosophila allynensis Bock, 1976:29.
PT ♀, Dorrigo National Park, N.S.W. K70580

Drosophila whianensis Bock, 1976:30.
HT ♀, Whian Whian State Forest, near Lismore, N.S.W. K70581

Drosophila macalpinei Bock, 1976:30.
HT ♀, Whian Whian State Forest, near Lismore, N.S.W. K70582
PT ♂, Upper Allyn, near Eccleston, N.S.W. K70583

Drosophila mixtura Bock, 1976:32.
HT ♂, PT ♂, Lake Barrine, Atherton Tableland, Qld. K70584-5

Drosophila palumae Bock, 1976:38.
HT ♀, 3km SW of Paluma, Qld. K70586

Drosophila lativittata Malloch, 1923a:618.
HT ♀, Sydney, N.S.W. K48513

Drosophila cancellata Mather, 1955:550.
ST 3♂, 3♀, Moggill, near Brisbane, Qld. K67778-83
Labelled HT ♂, AT ♀, and paratypes.

Drosophila obsoleta Malloch, 1923a:616.
HT ♀, Sydney, N.S.W. K48516

Drosophila inornata Malloch, 1923a:617.
HT ♀, Blue Mountains, N.S.W. K48514
The head, abdomen, a wing and the legs are missing from this specimen.

Drosophila rhabdote Bock, 1976:53.
HT ♀, Marakoopa Caves, near Mole Creek, Tas. K70587
PT ♂, Templestowe, Vic. K70588

Drosophila barkeri Bock, 1976:56.
HT ♀, Otford, N.S.W. K70589
PT ♂, Upper Allyn, near Eccleston, N.S.W. K70590

Drosophila exemplar, Bock, 1976:57.
HT ♀, Iluka, Clarence River, N.S.W. K70591

Drosophila concolor Bock, 1976:60.
HT ♂, Claudie River, near Mount Lamond, Qld. K70592

Drosophila mulgravei Bock, 1976:61.
HT ♂, PT ♂, Mulgrave River, 6km W of Gordonvale, Qld. K70593-4

Drosophila brunneipennis Malloch, 1923a:617.
HT ♀, Sydney, N.S.W. K48515

Drosophila levis Mather, 1955:561.
ST 3 ♂, 3 ♀, Maroochydore, Qld. K67805-10
Labelled HT ♂, AT ♀, and PT.
This is a synonym of *Drosophila bryani* Malloch (Mather, 1956:65).

Drosophila albostriata Malloch, 1924c:352.
HT ♀, PT 2 ♀, Eidsvold, Qld. K50091

Drosophila opaca Mather, 1955:558.
ST 3 ♂, 3 ♀, Noosa, Qld. K67793-8
Labelled HT ♂, AT ♀, and PT.
This is a synonym of *Drosophila subnitida* Malloch (Bock, 1976:74).

Drosophila maculosa Mather, 1955:560.
ST 3 ♂, 3 ♀, Moggill, Qld. K67799-804
Labelled HT ♂, AT ♀ and PT.
Drosophila novamaculosa Mather, 1956:65 (*maculosa* preoccupied).

Drosophila megagenys Bock, 1976:79.
HT ♀, Brown Mountain, near Nimmitabel, N.S.W. K70595

Drosophila parsonsi Bock, 1976:80.
HT ♀, Wilson's Promontory, Vic. K70596
PT ♂, Fernshaw, near Healesville, Vic. K70597

Drosophila fimbriata Bock, 1976:85.
HT ♂, St. Helen's Creek, Mackay district, Qld. K70598

Drosophila crocata Bock, 1976:93.
HT ♂, Mulgrave River, 6km W of Gordonvale, Qld. K70599

Leucophenga poeciliventris Malloch, 1923a:614.
HT ♀, Blue Mountains, N.S.W. K48520

Leucophenga scutellata Malloch, 1923a:614.
HT ♀, Sydney, N.S.W. K48517

Leucophenga niveifasciata Malloch, 1923a:614.
HT ♂, Woolgoolga, N.S.W. K48518

Leucophenga polita Malloch, 1923a:615.
HT ♀, Woolgoolga, N.S.W. K48521

Leucophenga conjuncta Malloch, 1924d:350.
HT ♂, no data. K50092

Amiota annulata Malloch, 1923a:612.
HT ♂, Eidsvold, Qld. K48523

Family MILICHIIDAE

Hypaspistomyia albipennis Malloch, 1924c:336.
HT ♂, Belaringar, N.S.W. K50093
This specimen is damaged.

Family CRYPTOCHETIDAE

Librella demetrius D. McAlpine, 1976:46.
HT ♀ , Wingabutta Creek, 37km N of Mendooran, N.S.W. K70600

Family CANACEIDAE

Trichocanace marksae Wirth, 1964:226.
PT 1♂, 1♀, Cairns, Qld. K68627-8

Family CHLOROPIDAE

Ephydroscinis raymenti Curran, 1930:1.
PT 2♀, Port Phillip, Vic. K66965
Lasiopleura raymenti (Curran) comb. nov.

Parahippelates costomaculata Malloch, 1924c:329.
HT ♂, Sydney, N.S.W. K50094
Lasiopleura costomaculata (Malloch) (Malloch, 1940:270).

Parahippelates albiseta Malloch, 1924c:330.
HT ♂, Eidsvold, Qld. K50096
Lasiopleura albiseta (Malloch) (Malloch, 1940:272).

Superfamily MUSCOIDEA
Family MUSCIDAE
Subfamily MUSCINAE

Musca terraereginae Johnston and Bancroft, 1920:31.
Paralectotypes, 1♂, 1♀, no data (possibly Eidsvold, Qld.). K70601

Musca hilli Johnston and Bancroft, 1920:35.
Paralectotype ♀, no data (possibly Eidsvold, Qld.). K70602
This is a synonym of *Musca terraereginae* Johnston and Bancroft, (Pont, 1973:180).

Subfamily FANNIINAE

Fannia australis Malloch, 1923a:605.
HT ♂, Sydney, N.S.W. K50114

Subfamily EGINIINAE

Neohelina flavomarginata Malloch, 1925:329.
HT ♀ , Myponga, S.A. K50101

Neohelina semivittata Malloch, 1924:415.
HT ♂ , Lowanna, East Dorrigo, N.S.W. K48522

Subfamily COENOSIINAE

Pectiniseta similis Pont, 1972:147.
HT ♂ , Mulgrave River, 6km W of Gordonvale, Qld. K70603
PT ♂ , Kuranda, Qld. K70604
PT 2♀, North Maria Creek, near Silkwood, Qld. K70605
PT ♀ , Mopo, near Babinda, Qld. K70606
The holotype has not been located in the collection.

Pectiniseta occulta Pont, 1972:149,
HT ♂, PT 1♂, 1♀, Claudie River, near Mount Lamond, Qld. K70607-8
The holotype has not been located in the collection.

Coenosia spumicola Pont, 1973a:179.
PT 3♂, Vaucluse, near Sydney, N.S.W. K70609-10

Atherigona tibiseta Malloch, 1924b:145.
HT ♂, Mosman, near Sydney, N.S.W. K50112

Subfamily PHAONIINAE

Prohardyia macalpinei Pont, 1969a:947.
HT ♀, Fernshaw, near Healesville, Vic. K70611
This specimen has not been located in the collection.

Ophyra pallicornis Pont, 1973:247.
HT ♀, Claudie River, near Mount Lamond, Qld. K70613

Helina flavofusca Malloch, 1924b:143.
HT ♀, Narrabeen, near Sydney, N.S.W. K50100

Helina hirtibasis Malloch, 1923:671.
HT ♂, Barrington Tops, N.S.W. K50099

Phaonia fergusoni Malloch, 1924b:141.
HT ♂, Allyn River, N.S.W. K50111

Xenolispa nigrimana Malloch, 1923a:611.
HT ♂, Burnett River, Qld. K50119
The head is missing from this specimen.

Anaclysta obliterata Malloch, 1923a:602.
HT ♂, Belaringar, Nevertire, N.S.W. K50109
Gymnodia obliterata (Malloch) (Pont, in press).

Anaclysta ruficornis Malloch, 1923a:602.
HT ♂, AT ♀, Eidsvold, Qld. K50108
Gymnodia ruficornis (Malloch) (Pont, in press).

Dichaetomyia parimpar Pont, 1969:219.
PT ♂, Upper Allyn, near Eccleston, N.S.W. K70614
PT ♂, Goondi Hill, near Innisfail, Qld. K70615
PT ♀, Mount Gibraltar National Park, N.S.W. K70616
PT ♀, Mulgrave River, 6km W of Gordonvale, Qld. K70617
PT ♀, North Bondi, near Sydney, N.S.W. K70168
PT ♂, Springwood, Blue Mountains, N.S.W. K70619

Dichaetomyia rufaeformis Pont, 1969:234.
PT 1♂, 2♀, Claudie River, near Mount Lamond, Qld. K70620-1
PT 2♂, Kuranda, Qld. K70622-23
PT ♂, Mulgrave River, 6km W of Gordonvale, Qld. K70624

Dichaetomyia australis Pont, 1969:239.
HT ♂, 4km N of Kuranda, Qld. K70625
PT 2♀, Mulgrave River, 6km W of Gordonvale, Qld. K70626-7
The holotype has not been located in the collection.

Dichaetomyia collessi Pont, 1969:257.
PT 2♀, Claudie River, near Mount Lamond, Qld. K70628-9
PT ♀, Kuranda, Qld. K70630

Dichaetomyia aseta Pont, 1969:260.
PT ♀, Claudie River, near Mount Lamond, Qld. K70631
PT 1♂, 4♀, Kuranda, Qld. K70632-5

Dichaetomyia fusconota Pont, 1969:266.
PT ♀, Kuranda, Qld. K70636

Dichaetomyia arrogans Pont, 1969:270.
PT 2♀, The Intake, via Redlynch, Qld. K70637
PT ♀, Mulgrave River, 6km W of Gordonvale, Qld.
PT ♀, Thornton Range, near Daintree River, Qld.
The last two specimens have not been located in the collection.

Family CALLIPHORIDAE
Subfamily CALLIPHORINAE

Calliphora canimicans G. Hardy, 1930:447.
ST 5♂, Brisbane, Qld. (Labelled paratypes). K63652

Calliphora fallax G. Hardy, 1930:446.
ST ♀ , Brisbane, Qld. (Labelled paratype). K63651

Calliphora fulvicoxa G. Hardy, 1930:445.
ST 2♂, 1♀, Brisbane, Qld. (Labelled paratypes). K63650

Calliphora perida G. Hardy, 1937:22.
ST 1♂, 1♀ , Brisbane, Qld. (Labelled paratypes). K67516

Subfamily AMENIINAE

Amenia sexpunctata Malloch, 1933:76.
PT♂ , Palmerston, N.T. K67931

Family SARCOPHAGIDAE

Helicobia australis Johnston and Tiegs, 1921:50.
PT ♂, Brisbane, Qld. K44358
Phytosarcophaga australis (Johnston and Tiegs) (de Souza Lopes, 1967:145).

Sarcophaga alpha Johnston and Tiegs, 1921:57.
PT ♂, Brisbane, Qld. K44348
Tricholioproctia alpha (Johnston and Tiegs) (de Souza Lopes, 1954:244).

Sarcophaga zeta Johnston and Tiegs, 1921:76.
PT ♂ , Brisbane, Qld. K45067
Tricholioproctia zeta (Johnston and Tiegs) (de Souza Lopes, 1954:240).

Sarcophaga beta Johnston and Tiegs, 1921:58.
PT 1♂, 2♀ , Brisbane, Qld. K44347
Tricholioproctia beta (Johnston and Tiegs) (de Souza Lopes, 1954:242).

Sarcophaga tryoni Johnston and Tiegs, 1921:54.
PT 2♂, 1♀ , Brisbane, Qld. K44350
Tricholioproctia tryoni (Johnston and Tiegs) (de Souza Lopes, 1954:258).

Sarcophaga hardyi Johnston and Tiegs, 1922:181.
ST 1♂, 1♀, Launceston, Tas. (Labelled "HT" and "AT"). K44452
Tricholioproctia hardyi (Johnston and Tiegs) (de Souza Lopes, 1954:261).

Sarcophaga theta Johnston and Tiegs, 1921:78.
PT 1♂, 2 ♀, Brisbane, Qld. K44343-4
This is a synonym of *Tricholioproctia froggatti* (Taylor) (de Souza Lopes, 1954:268).

Sarcophaga epsilon Johnston and Tiegs, 1922:180.
HT ♂, Brisbane, Qld. K44337
Tricholioproctia epsilon (Johnston and Tiegs) (de Souza Lopes, 1954:264).

Sarcophaga howensis Johnston and Hardy, 1923:65.
There is, in the collection, a ♂ labelled paratype, from Brisbane. As this specimen was not included in the type series, it has no status as a type.
1♂, Brisbane, Qld. K70673
Tricholioproctia howensis (Johnston and Hardy) (de Souza Lopes, 1954:274).

Sarcophaga littoralis Johnston and Tiegs, 1922:183.
ST 1♂, 1♀ , Caloundra, Qld. K44338
Hardyella littoralis (Johnston and Tiegs) (de Souza Lopes, 1959:38).

Sarcophaga fergusoni Johnston and Tiegs, 1922a:186.
HT♂, Allyn River, Eccleston, N.S.W. K44863
This is a synonym of *Fergusonimyia bancrofti* (Johnston and Tiegs) (de Souza Lopes, 1958:547).

Sarcophaga eta Johnston and Tiegs, 1921:65.
PT♂, Brisbane, Qld. K44346
Parasarcophaga eta (Johnston and Tiegs) (de Souza Lopes, 1959:64).

Sarcophaga sigma Johnston and Tiegs, 1921:84.
PT 1♂, 1♀, Brisbane, Qld. K44339
This is a synonym of *Parasarcophaga aurifrons* (Macquart) (Johnston and Hardy, 1923a:115).

Miltogramma rex Malloch, 1930a:442.
HT♂, King George Sound, W.A. K57967

Family TACHINIDAE
Subfamily PHASIINAE

Hyalomyia nigrisquama Malloch, 1929:110.
HT♂, French's Forest, near Sydney, N.S.W. K52617
Alophora nigrisquama (Malloch) (Crosskey, 1973a:110).

Cylindromyia fenestrata Paramonov, 1956:363.
HT♂, Gayndah, Qld. K68306

Cylindromyia westralica Paramonov, 1956:367.
HT♂, King George Sound, W.A. K68307

Cylindromyia angustissimifrons Paramonov, 1956:365.
PT♂, Canberra, A.C.T. K68308

Subfamily PROSENINAE

Heterometopia argentea Macquart, 1846:298.
There are, in the collection, two specimens from Dunalley, Tasmania, one of which is labelled allotype and designated by Hardy (1922a:199). As this specimen was not included in the type series, it cannot be considered to be a type.
1♀, Dunalley, Tas. K45270

Chaetogastrina stolida Malloch, 1929a:313.
HT♂, PT 3♂, Barrington Tops, N.S.W. K57973
Amphibolia stolida (Malloch) (Crosskey, 1973:101).

Formosia smaragdina Malloch, 1929a:312.
HT♀, Gordonvale, Qld. K41527
PT♀, Cairns, Qld. K70638

Prodiaphania georgei Malloch, 1929a:292.
HT♂, PT♂, King George Sound, W.A. K57954

Prodiaphania testacea var. *claripennis* Malloch, 1929a:292.
HT♂, King George Sound, W.A. K57941
Prodiaphania claripennis Malloch (Paramonov, 1968:390).

Rutilia formosa var. *subvittata* Malloch, 1929a:295.
HT♀, King George Sound, W.A. K57927

Rutilia micropalpis Malloch, 1929a:298.
HT♀, Como, near Sydney, N.S.W. K50140
PT♀, Gunnamatta Bay, Port Hacking, N.S.W. K55837

Rutilia micans Malloch, 1929a:299.
HT♀, PT 3♀, Kosciusko, N.S.W. K57937

Rutilia hirticeps Malloch, 1929a:305.
HT ♂, Moonbar, N.S.W. K57939
PT ♂, Ulong, near Dorrigo, N.S.W. K43218

Rutilia albovirida Malloch, 1929a:307.
HT ♀, Yeppoon, Qld. K50695
PT ♀, Yeppoon, Qld. K50700

Rutilia nigriceps Malloch, 1929a:306.
HT ♂, PT 2 ♂, Ulong, East Dorrigo, N.S.W. K43219-20
PT ♂, Ulong, East Dorrigo, N.S.W. K44234

Rutilia dubitata Malloch, 1929a:303.
HT ♀, Jindabyne, N.S.W. K57934
This species is a synonym of *Rutilia analoga* Macquart (Crosskey, 1973:72).

Formosia confusa Malloch, 1929a:309.
HT ♂, PT 1 ♂, 2 ♀, Deep Creek, 32km from Kingscote, Kangaroo Island, S.A. K42773
PT 2 ♀, Jindabyne, N.S.W. K57934
PT 3 ♀, Kosciusko, N.S.W. K57933
PT ♀, Berowra, near Hawkesbury River, N.S.W. K50223
Rutilia confusa (Malloch) (Enderlein, 1936:429).

Formosia frontosa Malloch, 1929a:310.
HT ♂, PT ♂, Jindabyne, N.S.W. K57965
This is a synonym of *Rutilia argentifera* Bigot (Crosskey, 1973:54).

Subfamily TACHININAE

Chlorotachina nigrocaerulea Malloch, 1929a:324.
HT ♂, King George Sound, W.A. K57942

Macrochloria calliphorosoma Malloch, 1929a:326.
HT ♂, Barrington Tops, N.S.W. K57974
AT ♀, PT 1 ♂, 1 ♀, Kosciusko, N.S.W. K57962
This is a synonym of *Macrochloria nitidiventris* (Macquart) (Crosskey, 1973a:132).

Microtropesa latimana Malloch, 1929a:287.
HT ♀, Queensland K36825
This is a synonym of *Microtropesa sinuata* (Donovan) (Hardy, 1939:34).

Microtropesa flavitarsis Malloch, 1929a:288.
HT ♂, Tasmania K57938

Subfamily GONIINAE

Schizotachina fergusoni Bezzi, 1923a:657.
HT ♂, Sydney, N.S.W. K48398
Ceromya fergusoni (Bezzi) (Crosskey, 1973a:137).

Zenargomyia moorei Crosskey, 1964:20.
HT ♂, Matong S.F., N.S.W. K68324
PT ♂, Wentworth Falls, Blue Mountains, N.S.W. K68325
PT ♂, Corringle S.F., N.S.W. K68326
PT ♀, Buckingbong S.F., N.S.W. K68327
PT ♀, Corringle S.F., N.S.W. K68328
PT ♀, Olney S.F., N.S.W. K68329
PT ♀, Corringle S.F., N.S.W. K68330
PT ♂, Lakeview S.F., N.S.W. K68331
PT ♀, Olney S.F., N.S.W. K68332
PT ♀, Dubbo, N.S.W. K68333
PT ♀, Olney S.F., N.S.W. K68334

PT ♂ , Mandalong, N.S.W. K68335
PT ♂ , Olney S.F., N.S.W. K68336
PT ♂ , Maroote, N.S.W. K68337
PT ♂ , Mandalong, N.S.W. K68338

Quadra ornata Malloch, 1929a:320.
HT ♂ , King George Sound, W.A. K57948

Zebromyia obesa Malloch, 1929a:321.
HT ♂ , PT ♂ , Tasmania K57951
This species is a synonym of *Zebromyia ornata* (Macquart) (Hardy, 1938a:59).

Metaphryno bella Crosskey, 1967:29.
PT ♂, Sawpit Creek, Mount Kosciusko, N.S.W.
This specimen has not been located in the collection.

Phorocerosoma setiventris Malloch, 1929a:327.
HT ♂ , National Park, Macpherson Range, Qld.
Phorocerostoma setiventris (Malloch) (Malloch, 1930:326).
This specimen has not been located in the collection.

Family HIPPOBOSCIDAE

Ortholfersia bequaerti Maa, 1962:606.
HT ♂ , AT ♀ , Moreton Bay, Qld. K36959

Family STREBLIDAE

Brachytarsina mackeani Maa, 1971:10.
HT ♂ , Lankelly Creek, Coen, Qld. K68767

Brachytarsina amboinensis uniformis Maa, 1971:11.
HT ♀ , PT 22 ♂, 20 ♀, Possession Island, Torres Strait, Qld. K68677-8
PT 1 ♂, 3 ♀ , Carrai, via Kempsey, N.S.W. K68679
PT ♂ , Whitsunday Island, Qld. K68680
PT 1♂, 8 ♀ , Elizabeth Bay House, Sydney, N.S.W. K68681
PT 5 ♀, Fitzroy Vale, near Rockhampton, Qld. K68682
PT 1♂ , 2 ♀ , Prospect Reservoir, N.S.W. K68683
PT ♀ , Cairns, Qld. K68684
PT ♀ , Lindeman Island, Qld. K68771

Family NYCTERIBIIDAE

Cyclopodia similis Speiser, 1900:292.
Lectotype ♀ , paralectotype ♀ , Mapoon Mission, Batavia River, Qld. K15789
This species is a synonym of *Cyclopodia albertisii* Rondani (Maa, 1971:21).

Basilia techna Maa, 1971:38.
PT ♂ , The Cave, near Mount Cityan, Qld. K68769
PT ♀ , Louie Creek, 13km SW of Adel's Grove, via Lawn Hill, Qld. K68770

Nycteribia longispinosa Musgrave, 1927:274.
HT ♀ , PT 3 ♀, Sans Souci, Sydney, N.S.W. K51807-10
AT ♂ , Sans Souci, Sydney, N.S.W. K51805
Basilia longispinosa (Musgrave) (Maa, 1965:30).

Nycteribia multispinosa Musgrave, 1927:268.
HT ♀ , Berrima, N.S.W. K55122
AT ♂ , PT 3 ♂, 3 ♀ , Berrima, N.S.W. K55125-31
Basilia multispinosa (Musgrave) (Maa, 1965:380).

Basilia hamsmithi Maa, 1971:46.
PT ♀ , Cunnamulla, Qld. K68772

Basilia aitkeni Maa, 1971:49.
PT ♂, 2km N of Lawn Hill Station, Qld. K68768

Basilia barbarae Maa, 1971:51.
PT 4♂, 3♀, near Bircheno, Tas. K51812-8

Nycteribia falcozi Musgrave, 1925:292.
HT ♂, PT 1♂, 1♀, Mount Lyndhurst, 48km E of Farina, S.A. K48158
AT ♀, PT ♀, Mount Lyndhurst, 48km E of Farina, S.A. K48163-4
PT 3♂, Mount Lyndhurst, 48km E of Farina, S.A. K42924
Basilia falcozi (Musgrave) (Maa, 1965:380).

Nycteribia halei Musgrave, 1927:271.
HT ♀, cave at Arkaba, S.A. K51821
AT ♂, cave at Arkaba, S.A. K51819
Basilia halei (Musgrave) (Maa, 1965:380).

Basilia nodulata Maa, 1971:59.
HT ♂, Hazelbrook, Blue Mountains, N.S.W. K49851

Nycteribia brevicauda Musgrave, 1925:295.
HT ♂, Hazelbrook, Blue Mountains, N.S.W. K49848
AT ♀, Hazelbrook, Blue Mountains, N.S.W. K49850
Basilia brevicauda (Musgrave) (Maa, 1965:380).

Nycteribia troughtoni Musgrave, 1927:265.
HT ♀, PT ♀, Glenroy, Hartley, N.S.W. K51801-2
PT 2♀, Smithfield, near Fairfield, N.S.W. K51803-4
PT ♂, Munni, Williams River, N.S.W. K47880
Basilia troughtoni (Musgrave) (Maa, 1965:380).

Nycteribia burrelli Musgrave, 1927:272.
HT ♀, AT ♂, Caermarthen, Manilla, N.S.W. K51822-3
Basilia burrelli (Musgrave) (Maa, 1965:380).

Nycteribia allotopa meridiana Maa, 1971:90.
PT ♀, Whitsunday Island, Qld. K68674

Nycteribia parilis vicaria Maa, 1971:90.
PT 28♂, Prospect Reservoir, N.S.W. K68685
PT 32♀, Piano Cave, Coolong Caves, N.S.W. K68687
PT 14♂, Elizabeth Bay House, near Sydney, N.S.W. K68688
PT 4♀, Bulladelah, N.S.W. K68689
PT ♂, Carrai, via Kempsey, N.S.W. K68690
PT 9♂, 4♀, Ashford Downs, N.S.W. K68691
PT 3♂, 2♀, Possession Island, Torres Strait, Qld. K68692
PT 2♂, 1♀, Whitsunday Island, Qld. K68693
PT 31♂, Piano Cave, Coolong Caves, N.S.W. K68694
PT 16♀, Elizabeth Bay House, N.S.W. K68695
PT 9♀, Prospect Tunnel, Prospect Reservoir, N.S.W. K68696

PACIFIC ISLAND TYPES
Suborder NEMATOCERA
Division CULICOMORPHA
Family SIMULIIDAE

Austrosimulium longicorne Tonnoir, 1925:254.
PT 2♂, Nihotapu, New Zealand K51180

Austrosimulium ungulatum Tonnoir, 1925:250.
PT ♀ , Kaikoura, New Zealand K51181
PT ♀ , Reefton, New Zealand K51182

Austrosimulium tillyardi Tonnoir, 1925:253.
PT 1♂, 1♀ , Nelson, New Zealand K51183

Suborder BRACHYCERA
Division ORTHORRHAPHA
Superfamily TABANOIDEA
Family RHAGIONIDAE

Chrysopilus howei Paramonov, 1962:119.
HT ♂, AT ♀ , PT ♂, Erskine Valley, Lord Howe Island K68557-9

Family XYLOMYIDAE

Solva atrata Daniels, 1977:456.
HT ♂ , Musgrave River, near Port Moresby, Papua New Guinea K70374
PT 7♂, 1 ♀, Kuminibus, near Maprik, Papua New Guinea K70376-7
PT 7♂, Imbia, near Maprik, Papua New Guinea K70375
PT ♀ , Awala Estate, Popondetta subdistrict, Papua New Guinea K70378

Solva melanogaster Daniels, 1977:455.
HT ♀ , Aroana Estate, Aroa River, Papua New Guinea K70371
PT 1♂, 1♀ , Upper Manki Logging area, near Bulolo, Papua New Guinea K70372-3

Solva laeta Daniels, 1977:456.
PT ♂ , Aroana Estate, Aroa River, Papua New Guinea K70381

Solva bergi James, 1951:149.
PT 1♂, 1♀ , Guadalcanal, Solomon Islands K70382-3

Division CYCLORRHAPHA
Series SCHIZOPHORA
Superfamily TEPHRITOIDEA
Family OTITIDAE

Hypsomyia goilala D. McAlpine, 1964:218.
HT ♂ , PT 3♂, 3♀ , Sidibamul, Wharton Range, Papua New Guinea .. K68428-34
Rhadinomyia goilala (McAlpine) comb. nov.

Family PLATYSTOMATIDAE

Achiosoma nigrifacies Malloch, 1939:131.
HT ♀ , Mount Lamington district, Papua New Guinea K68639

Duomyia howensis D. McAlpine, 1973:123.
PT ♀ , Lord Howe Island K70131
PT ♀ , Lord Howe Island K45773

Superfamily MICROPEZOIDEA
Family MICROPEZIDAE

Papeza szentivanyi D. McAlpine, 1975:242.
HT ♂ , PT 2♂, Woitape, Wharton Range, Papua New Guinea K70254-5

Superfamily HELEOMYZOIDEA
Family COELOPIDAE

Chaetocoelopa huttoni Harrison, 1959:103.
PT ♂ , Little Barrier Island, New Zealand K70706
PT ♀ , Boulder Beach, Little Barrier Island, New Zealand K70707

Family HELEOMYZIDAE

Cairnsimyia crosskeyi D. McAlpine, 1968:274.
PT ♂, Wau, Morobe District, Papua New Guinea K69177

Cairnsimyia aroana D. McAlpine, 1968:275.
HT ♂, PT 3 ♂, 2 ♀, "Aroana", Aroa River, Papua New Guinea K69178-83

Family SPHAEROCERIDAE

Leptocera papuana Richards, 1973:308.
HT ♂, PT ♀, Bainyik, Papua New Guinea K70403-4
PT ♀, Buri, near Sasembata, Popondetta subdistrict, Papua New Guinea K70405
PT ♀, Woitope, Wharton Range, Papua New Guinea K70406

Leptocera aroana Richards, 1973:310.
HT ♂, PT 6 ♂, 18 ♀, Aroana Estate, Aroa River, Papua New Guinea ... K70408-10

Leptocera macalpinei Richards, 1973:311.
HT ♂, PT 7 ♂, 5 ♀, Bainyik, Papua New Guinea K70411-7
PT 2 ♀, Kuminibus, near Maprik, Papua New Guinea K70418

Leptocera territorialis Richards, 1973:313.
HT ♂, PT 15 ♂, 15 ♀, Bainyik, Papua New Guinea K70419-23
PT 1 ♂, 2 ♀, Aroana Estate, Aroa River, Papua New Guinea K70426-7
PT ♂, Woitope, Wharton Range, Papua New Guinea K70424
PT ♂, Musgrave River, near Port Moresby, Papua New Guinea K70425

Leptocera vittigera Richards, 1973:357.
HT ♂, Buri, near Sasembata, Popondetta subdistrict, Papua New Guinea K70476

Leptocera scrobifera Richards, 1973:360.
HT ♂, Bainyik, Papua New Guinea K70480

Leptocera awalensis Richards, 1973:374.
HT ♂, Awala Estate, Popondetta subdistrict, Papua New Guinea K70485

Leptocera tetrasticha Richards, 1973:380.
HT ♂, Bainyik, Papua New Guinea K70490

Superfamily DROSOPHILOIDEA
Family EPHYDRIDAE

Stratiothyrea cheesmanae Cogan and Wirth, 1969:176.
PT 54 ♂, 27 ♀, Bainyik, Papua New Guinea K70689-90
PT 1 ♂, 2 ♀, Apangai, near Maprik, Papua New Guinea K70691-2
PT ♂, Musgrave River, near Port Moresby, Papua New Guinea K70693
PT ♀, Imbia, near Maprik, Papua New Guinea K70694
PT 2 ♂, Embala River, near Ajeka, Popondetta subdistrict,
Papua New Guinea K70695

Family DROSOPHILIDAE

Drosophila pseudotetrachaeta Angus, 1967:37.
HT ♂, AT ♀, Brown River, Papua New Guinea K68730-1

Drosophila pseudomayri Baimai, 1970:22.
ST 1 ♂, 1 ♀, Bulolo, Papua New Guinea K70643-4
Each specimen is labelled holotype.

Drosophila silvistriata Bock and Baimai, 1967:20.
HT ♂, AT ♀, Bulolo, Papua New Guinea K68670

Drosophila nigrilineata Angus, 1967:32.
HT ♂, AT ♀, Bulolo, Papua New Guinea K68728-9

Drosophila tetrachaeta Angus, 1964:156.
HT ♂, AT ♀ , Bulolo, Papua New Guinea K70645-6

Drosophila szentivanii Mather and Dobzhansky, 1962:247.
HT ♂ , Lae, Papua New Guinea K70647
This specimen is represented by a micropin mounted in pith and labelled holotype.

Drosophila mayri Mather and Dobzhansky, 1962:245.
HT ♂ , Bulolo, Papua New Guinea K70648
The abdomen is missing from this specimen.

Drosophila argentostriata Bock, 1966:273.
HT ♂ , AT ♀ , Bisianumu, Papua New Guinea K68625-6

Superfamily MUSCOIDEA
Family MUSCIDAE
Subfamily MUSCINAE

Ebenia fieldi Rainbow, 1897:98.
HT ♀ , Funafuti Atoll, Ellice Islands K70649
This is a synonym of *Musca sorbens* Wiedemann (Pont, 1968:90).

Ebenia nigricruris Rainbow, 1897:98.
HT ♂ , Funafuti Atoll, Ellice Islands K70650
This is a synonym of *Musca sorbens* Wiedemann, (Pont, 1968:90).

Degeeria dawsoni Rainbow, 1897:97.
Lectotype ♂, paralectotypes 1♂, 2♀, Funafuti Atoll, Ellice Islands K70651
This is a synonym of *Musca domestica* Linnē (Pont, 1968:89).

Subfamily COENOSIINAE

Lispe vittata Rainbow, 1897:97.
HT ♀ , Funafuti Atoll, Ellice Islands K70652
Atherigona vittata (Rainbow) (Pont, 1968:90).

Subfamily PHAONIINAE

Helina liepae Pont, 1973a:185.
HT ♂ , PT 2♂, 4♀ , near Ned's Beach, Lord Howe Island K70657-60
PT 2♀ , Old Settlement, Lord Howe Island K70661-2
PT ♀ , Blinky Beach, Lord Howe Island K70663

Spilogona ferrari Pont, 1973a:191.
PT 1♂, 2♀ , Ball Bay, Norfolk Island K70664

Subfamily MYDAEINAE

Papuaia asternata Vockeroth, 1972:25.
PT ♀ , Kunai Creek, Wau, Morobe District, Papua New Guinea K70665

Gymnopapuaia conformis Vockeroth, 1972:35.
PT ♂ , Aroana Estate, Aroa River, Papua New Guinea K70666

Gymnopapuaia clavipalpis Vockeroth, 1972:38.
PT ♂ , Imbia, near Maprik, Papua New Guinea K70667
PT 1♂, 1♀ , Mount Lamington district, Papua New Guinea K70668

Hebecnemia rufula Vockeroth, 1972:68.
PT ♀ , Musgrave River, near Port Moresby, Papua New Guinea K70669

Family CALLIPHORIDAE

Calliphora neozealandica Murray, 1954:713.
PT 1♂, 10♀ , Orongaronga, New Zealand K70670
PT 2♂, 5 , Wallaceville, New Zealand K70671

Family SARCOPHAGIDAE

Sarcophaga milleri Johnston and Tiegs, 1922:185.
ST 1♂, 1♀, New Zealand (Labelled HT and AT) K44352
This is a synonym of *Hybopygia varia* Walker (de Souza Lopes and Albuquerque, 1955:113).

Sarcophaga howensis Johnston and Hardy, 1923:65.
HT ♂, PT 2♂, Lord Howe Island K70672
Tricholioproctia howensis (Johnston and Hardy) (de Souza Lopes, 1954:274).

Sarcophaga multicolor Johnston and Tiegs, 1922:187
HT ♂, Rabaul, New Britain K40167
Johnstonimyia multicolor (Johnston and Tiegs) (de Souza Lopes, 1959:55).

Family NYCTERIBIIDAE

Cyclopodia planipyga Maa, 1968:19.
PT 2♂, 1♀, Tanna, New Hebrides K68675

NORTH AMERICAN TYPES

Family OTITIDAE

Haigia nevadana Steyskal, 1961:406.
PT ♂, Winnemucca, Nevada, U.S.A. K70675

Family MICROPEZIDAE

Compsobata columbiana Merritt and Peterson, 1976:1494.
PT 1♂, 1♀, 51km SW of Terrace, British Columbia, Canada K70674

Family HELEOMYZIDAE

Borboropsis steyskali Mathis, 1973:374.
PT 1♂, 1♀, H. J. Andrews Experimental Forest, near Blue River, Oregon, U.S.A. K70705

AFRICAN TYPES
(MADAGASCAN SUBREGION)
Family NYCTERIBIIDAE

Nycteribia fryeri Scott, 1914:217.
ST 1♂, 1♀, Assumption Islands, southern Indian Ocean K53065
Labelled paratypes.

ORIENTAL TYPES
Family CANACEIDAE

Trichocanace atra Wirth, 1964:227.
PT 1♂, 2♀, Bangphra, Cholburi, Thailand K68629-31

LIST OF DAMAGED HARDY TYPES

Family RHAGIONIDAE

Austroleptis rhyphoides G. Hardy, 1920:127.
PT ♂, Mount Wellington, Tas.
A wing is damaged, four legs and the antennae are missing from this specimen.
2 PT Mount Wellington, Tas.
The wings, part of the thorax and some legs are all that remain of each specimen.

Atherimorpha vernalis montana G. Hardy, 1927:125.
PT Mount Wellington, Tas.
This specimen has the abdomen missing, and has a covering of mould.
PT Cradle Mountain, Tas.

The wings, part of the thorax and two legs mounted on a pin are all that remain of this specimen.
Atherimorpha montana Hardy (Paramonov, 1962:161).

Atherimorpha fulva G. Hardy, 1927:126.
There is a ♂ from Zeehan, Tasmania, labelled paratype and in relatively good condition, in the collection. As this specimen was not included in the type series, it cannot be considered to be a type.

Family STRATIOMYIDAE

Antissella angustifrons G. Hardy, 1932a:47.
HT ♀, Brisbane, Qld.
A pin with the remains of the thorax, two legs and a slide with the abdomen are all that remain of the specimen.

Lecogaster cyanea White, 1916:79.
There is a badly damaged ♀ labelled allotype and a ♂ and a ♀, each labelled paratype, with the heads missing and traces of mould that cannot be considered as types as they were not part of the type series.
Lecomyia cyanea (White) (Hardy, 1932a:45).

Lecomyia notha G. Hardy, 1932a:46.
ST 2♂, Cleveland, Qld. (Labelled AT and PT). K70529
Both these specimens are badly damaged.

Actina brevihirta G. Hardy, 1932a:42.
ST 2♂, Brisbane, Qld.
The head is missing from each specimen.

Actina ocinis G. Hardy, 1932:52.
7 ST, Brisbane, Qld. (Labelled PT).
Six of these specimens are all badly damaged, the wings and thorax being intact on five specimens.

Damaromyia clivosa G. Hardy, 1931:128.
ST ♀, Brisbane, Qld. (Labelled HT). K70532
This specimen has the head missing and is in bad condition.

Family NEMESTRINIDAE

Cyclopsidea hardyi Mackerras, 1925:559.
HT ♂, Inglewood, Qld.
This specimen is represented only by the genitalia, mounted on a slide and pinned.

Trichophthalma rufonigra Mackerras, 1925:513.
PT ♂, Barrington Tops, N.S.W.
This specimen is represented only by the genitalia, mounted on a slide and pinned.

Family ASILIDAE

Clinopogon maritima G. Hardy, 1934a:511.
ST 2♂, Southport, Qld. (Labelled HT and AT).
Both these specimens are represented by the genitalia, mounted on a slide and pinned.

Nerterhaptomenus morus G. Hardy, 1934a:523.
4 ST, Brisbane, Qld. (Labelled HT and PT).
Each of these specimens is represented by a poorly made slide of various parts of the specimen. Nothing otherwise remains of the specimens except for one pin with the remains of the hind legs and abdomen.

Leptogaster occidentalis White, 1914:267.
HT♂ , Perth, W.A.
This specimen is glued to a card. The wings, part of the abdomen including the genitalia and parts of the legs remain.

Family APIOCERIDAE

Apiocera maritima G. Hardy, 1933:416.
ST 1♂, 1♀, Southport, Qld. (Labelled PT).
These specimens are represented by the genitalia, mounted on a slide and pinned.

Family EMPIDIDAE

Empis tibialis G. Hardy, 1934b:178.
ST 2♂, Cradle Mountain, Tas. (Labelled PT).
Two legs, a wing and part of the thorax are the only remains of one specimen. The other specimen has the abdomen and three legs missing.

Empis tenuirostris Thomson, 1868:473.
There are eight pins labelled as paratypes of this species from Blackheath, N.S.W. Five specimens are completely destroyed, two have the remains of the thorax, a wing and some legs, whilst the remaining specimen is in relatively good condition. Hardy (1934b:177) designated these specimens as types, but as they were not from the type series, they can have no status as types.

Family DOLICHOPODIDAE

Heterospilosus squamifer G. Hardy, 1958:295.
5 ST, Katoomba, N.S.W. (Labelled PT).
All specimens have extensive areas of damage.

Family CALLIPHORIDAE

Calliphora canimicans G. Hardy, 1930:447.
ST 38♂, Brisbane, Qld. (Labelled HT and PT).
Most of these specimens are represented only by the genitalia, mounted on a slide and pinned. Six specimens remain on the pins, but these are all badly damaged.

Calliphora fulvicoxa G. Hardy, 1930:445.
ST ♂ , Brisbane, Qld. (Labelled PT).
This specimen is badly damaged.

Calliphora perida G. Hardy, 1937:22.
ST 12♂, Brisbane, Qld. (Labelled HT and PT).
These specimens are represented by the genitalia, mounted on a slide and pinned. Two badly damaged specimens remain on the pins.

Calliphora bezzii G. Hardy, 1932c:551.
ST 11♂ , Seaford, Vic. (Labelled PT)
One specimen has a wing missing, another has the head missing. The remaining specimens are represented by the genitalia mounted on a slide and pinned

Pollenia flindersi G. Hardy, 1932b:338.
ST 3♂, Flinders, Vic. (Labelled HT and PT). K68566
These specimens are represented by three pins, each with genitalia, mounted on a slide, one pin bearing the thorax and a wing of the specimen.

Pollenia calamisessa G. Hardy, 1932b:340.
ST♂ , Brisbane, Qld. K68567

This specimen is represented by a pin with genitalia, mounted on a slide, nothing other wise remaining of the specimen.

Family SARCOPHAGIDAE

Sarcophaga kohla Johnston and Hardy, 1923a:113.
There is, in the collection, the remains of a specimen labelled allotype from Great Palm Island, Qld. As this specimen was not included in the type series it has no status as a type. Only the empty pupal case remains.
Parasarcophaga kolha (Johnston and Hardy) (de Souza Lopes, 1959:62).

Sarcophaga karnyi G. Hardy, 1927a:454.
PT 1♂, 1♀, Buitenzorg, Java
Only the empty pupal cases remain of these specimens.
Boettcherisca karnyi (Hardy) (de Souza Lopes, 1958a:32).

Sarcophaga antilopoides G. Hardy, 1927a:448.
13 PT, Buitenzorg, Java
Only the wings, part of the thorax and some legs remain of one specimen. The remainder are represented only by empty pupal cases.

Family TACHINIDAE

Zosteromyia longicornis G. Hardy, 1934:36.
Paralectotype ♂, Mount Glorious, Brisbane, Qld.
This specimen is badly damaged.
This is a synonym of *Zosteromeigenia mima* Townsend (Crosskey, 1973a:141).

Zosteromyia morgani G. Hardy, 1934:37.
Paralectotype ♂, Binniguy, N.S.W.
The remains of a wing and a pupal case are all that remain of this specimen.
Medinodexia morgani (Hardy) (Crosskey, 1973a:140).

Tritaxys heterocera (Macquart), 1844:153.
There is in the collection, the remains of a specimen of this species labelled paratype from Melbourne, Victoria, and designated by G. Hardy (1938a:62). As this specimen was not included in the type series, it has no status as a type. The specimen is represented by a pin with genitalia mounted on a slide, nothing otherwise remaining of the specimen.

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ADDENDA
AUSTRALIAN ASILIDAE

Neoitamus neoclaripes G. Hardy 1921c: 295.
PT 2♂, 2♀, Blackheath, N.S.W. K43197
Cerdistus neoclaripes (Hardy) (Hardy 1926:648).

Neoitamus gibbonsi Ricardo, 1918:64.
ST 1♂, 1♀, Sydney, N.S.W. (labelled PT) K70915
Cerdistus gibbonsi (Ricardo) (Hardy, 1926:652).

REPRODUCTIVE STRUCTURES OF THE GLOSSOPTERIDALES IN THE PLANT FOSSIL COLLECTION OF THE AUSTRALIAN MUSEUM

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SUMMARY

A new, Late Permian *Glossopteris* fructification genus *Squamella* is erected. It comprises cones (the 'terminal buds' of Walkom, 1928) which are aggregations of 'scale-fronds' bearing sporangia or seeds. The cones are borne terminally on branchlets which had foliage leaves in whorls or close spiral arrangement, and modified, gangamopteroid leaves preceded the cones. Scale-fronds were composed of a deciduous scale (the 'squamae' of *Glossopteris* assemblages) and a laminal segment. Fructifications were attached to the scale-fronds at the line of junction of scale and lamina. Three new species of the genus are described: *Squamella australis,* which is the male cone of *Glossopteris linearis* McCoy and is known in attachment to a leaf whorl of that species; *Squamella ampla,* which is referred to *Glossopteris ampla* Dana; and *Squamella ovulifera,* which is a female cone whose foliage is unknown. "*Lidgettonia australis* White 1964" is redescribed and emended and is incorporated in *Squamella australis*.

The description of *Glossopteris linearis* McCoy is amplified, on vegetative, reproductive and internal anatomical evidence.

Two new species of *Partha* are described, as well as examples of *Eretmonia, Rusangea* and *Lidgettonia*.

Multiovulate fructifications referable to *Dictyopteridium, Scutum,* and *Plumsteadia (Cistella)* are included, and a controversial fructification which may be referable to *Vannus*. Some specimens of *Rigbya arberioides* which might possibly be glossopteridalean are illustrated.

Part 1: Review of '*LIDGETTONIA AUSTRALIS* White' and formation of *SQUAMELLA* GEN NOV.

In 1964 (White, 1964) a series of progressively modified leaves, believed to be referable to *Glossopteris angustifolia* Bgt. was described, culminating in fertile 'scale-fronds' which bore fructifications at the line of junction of scale and lamina. The series and the fertile scale-fronds were named *Lidgettonia australis* as there was insufficient evidence available from the limited number of specimens from the Bowen Basin, Queensland, to create a new genus. The genus *Lidgettonia* Thomas 1958 was, at that time, the only glossopteridalean fructification which involved a modified small leaf.

Recently a great deal of research has been done in India (summarised by Surange and Chandra, 1975) and in Africa (summarised by Lacey et al., 1975) and a number of genera have been described in which reproductive structures are borne on small, modified leaves or scales.

In the Plant Fossil Collection of the Australian Museum are many fructifications referable to most Glossopterid reproductive structure genera so far described, and in addition, much material of '*Lidgettonia australis*'. The information is unusually complete and it is possible to describe the reproductive structures in detail, to show them attached

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Records of The Australian Museum, 1978, **Vol. 31, No. 12,** 473-505, Figures 1-68

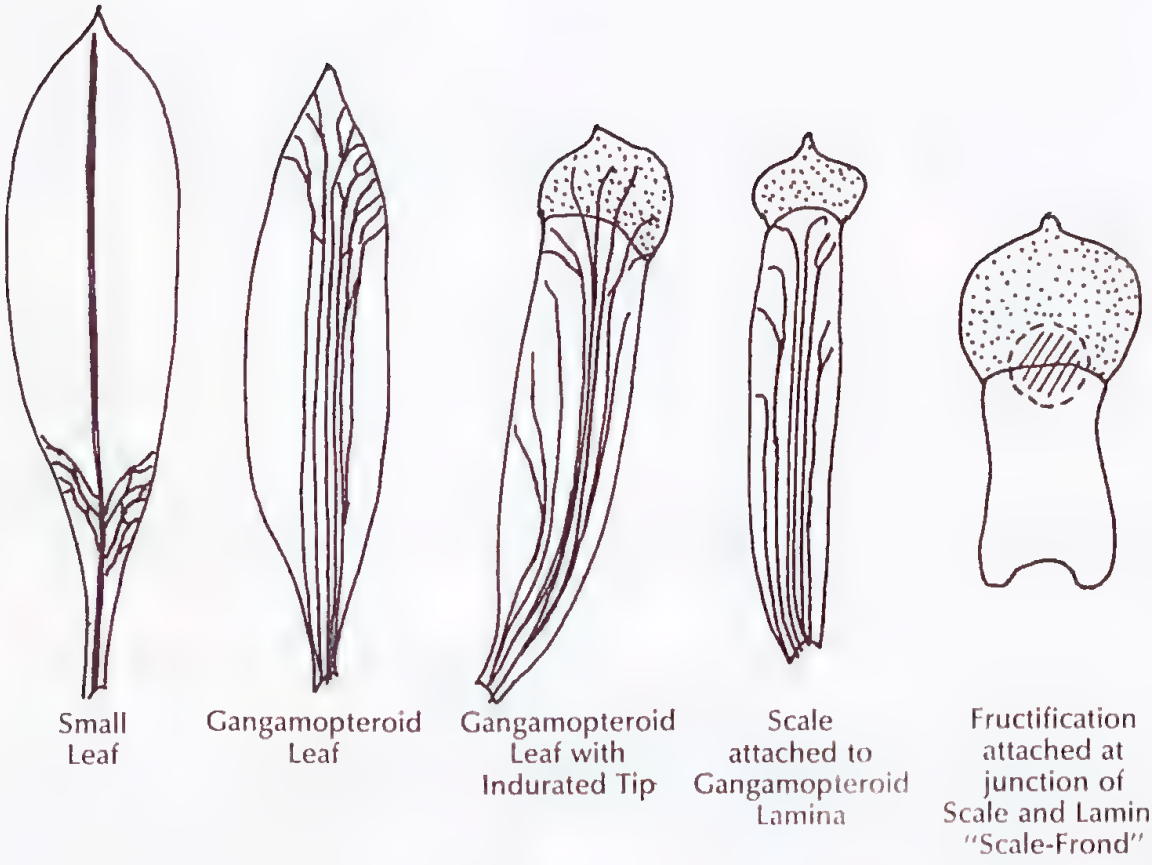

Small Leaf
Gangamopteroid Leaf
Gangamopteroid Leaf with Indurated Tip
Scale attached to Gangamopteroid Lamina
Fructification attached at junction of Scale and Lamina "Scale-Frond"

Fig. 1. Diagrammatic representation of *"Lidgettonia australis."* Progressive modification from small leaves; to gangamopteroid small leaves; to gangamopteroid leaves with indurated tips which become squamous; to scale-fronds. Scale-fronds have a gangamopteroid laminal segment and attached squama and the fructification is attached at the junction of scale and lamina.

to the plant, and to investigate the stem structure of a branchlet bearing the same leaves as those associated with the fertile phase. It is necessary to erect a new genus and to incorporate *Lidgettonia australis* in it.

The progressive modification from small leaves to scale-fronds as described by White, 1964, is shown to be valid. Whereas *Lidgettonia, Partha, Denkania* and *Glossotheca* have a modified, gangamopteroid leaf bearing cupules or sporangia on forking pedicels, and *Eretmonia* bears similar forked pedicels on the petiole of its intermediate-type scale like, modified leaf, the new genus here described has distinct differences. The concave scales are deciduous and as fossils normally occur detached. The texture of the scales was presumably papery or woody. Sporangial clusters were made from an aggregation of forking 'threads' of sporangia attached along the line of junction of the scale and lamina.

Scale-fronds are aggregated into cones which are borne at the ends of foliage-bearing branchlets with leaves in whorled or close-spiral formation. Modified small, gangamopteroid leaves precede the cone structures.

Because the scales associated with the reproductive structures are squamae and not leaf-like, the name *Squamella* is given to the genus. In the Australian Museum Collection, material of *Squamella australis* occurs at many localities in Late Permian strata, always associated with a *Glossopteris* with long, narrow leaves, and in one specimen attached to a stem bearing leaves of this type. The Bowen Basin material (White, 1964) was described as being the fertile phase of *Glossopteris angustifolia* Bgt. As determination of similar leaves is still unsatisfactory on gross morphology, a problem arises in naming the vegetative leaves of the specimens under discussion. A specimen in which a whorl of leaves is attached to a stem whose internal structure was preserved was referred to *Glossopteris linearis* McCoy 1874 by Etheridge (1894). *Squamella australis* is referred to *Glossopteris linearis* so as not to imply that all the many leaves referred to *Glossopteris angustifolia* are from plants whose reproductive phase was *S. australis*.

Type material of *"Lidgettonia australis* White" was kindly lent by the Bureau of Mineral Resources, Canberra, for re-examination. Figures 10-13 illustrate specimens which now become paratypes for *Squamella australis*. In accordance with the procedure laid down in "Principles of Palaeontology" (Raup & Stanley, 1971) a holotype, the most complete specimen, and a series of paratypes is used to express the concept of the species, and to show the elements of the composite structures involved.

An understanding of *Squamella australis* has led to the identification of *Squamella ampla*, which is described in (b) of Part 1 below and is illustrated in Figures 27-31. It is believed to be the cone structure of *Glossopteris ampla* Dana whose very large leaves are in keeping with the size of the cone and its component parts.

Genus **Squamella** gen. nov.

Type species *Squamella australis* (White)
Syn. *Lidgettonia australis* White 1964

DIAGNOSIS: Reproductive structure genus of *Glossopteris*.

Cones formed by aggregation of squamous scale-fronds, each composed of a scale and a laminal segment, and each bearing a reproductive structure at the line of junction of scale and lamina. The "terminal buds" of Walkom, 1928, are complete *Squamella* cones. The scale-fronds of *Lidgettonia australis* White 1964 are incorporated in *Squamella*. There are small, gangamopteroid, sterile leaves associated with the cones,

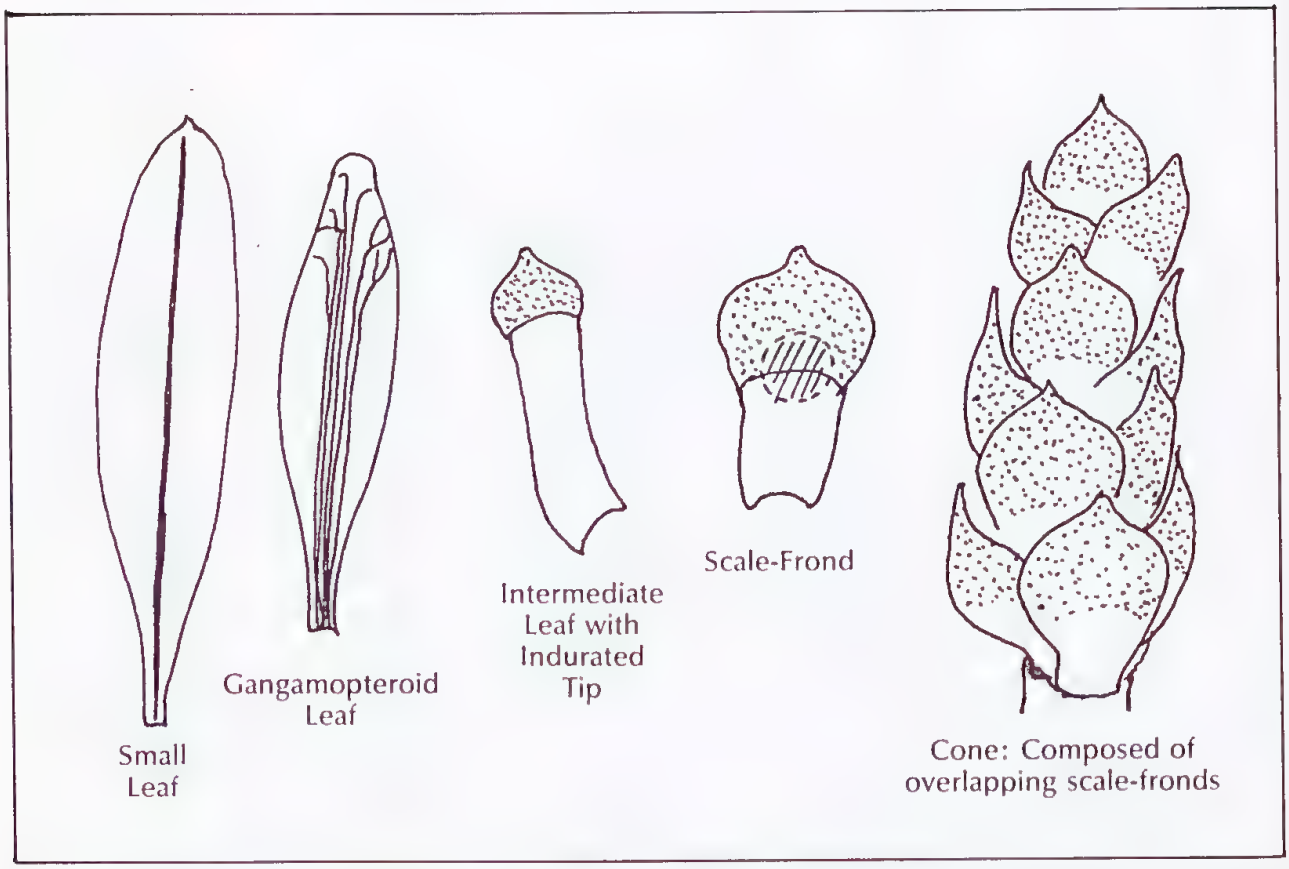


Fig. 2. Diagrammatic Representation of *Squamella australis*. Progressive modification from small leaf; to gangamopteroid small leaf; to gangamopteroid lamina with squamous tip; to scale-frond consisting of squama and laminal segment with fructification attached at junction of lamina and scale; the scale fronds are aggregated into cones.

and some of these show serial modification towards scale-fronds with induration of tips. Squamae are deciduous and are mostly fossilised separately from the laminal segments, sporangial clusters, and residual cores. The cones were borne at the ends of branchlets which had leaves in whorls or close spirals. Modified leaves formed a whorl between the cone and the foliage leaves. There is evidence that ripening of the cones and shedding of the sporangia was achieved by elongation of the laminal sections of scale-fronds.

In *S. australis* the reproductive structures are male sporangia of *Arberiella* type (Pant & Nautiyal, 1960). In *S. ampla* they are assumed to be male. A specimen described as *S. ovulifera* is described in (c) below. It bears stalked seeds at junction of scale and lamina.

Squamella australis (White)

DIAGNOSIS: Cones composed of scale-fronds in which the scales are pointed, pear-shaped, often deeply concave. The complete cone measures 6 cm. long, is widest at the base, maximum width 2 cm, and tapers to an acute apex. Scales overlap in close spiral arrangement, three to each slightly oblique whorl. Laminal segments were as long as, or shorter than, the scale. Sporangial clusters contained more than fifty sporangia.

At the base of the cone, gangamopteroid small leaves and small leaves modified to the extent that they had an indurated tip (intermediate between scale-fronds and gangamopteroid leaves) formed a whorl or whorls. Foliage leaves with characteristic form and appearance of *Glossopteris linearis* McCoy formed a whorl below these.

DESCRIPTION OF SPECIMENS: Holotype F 57342, 57341. (F 57343 counterpart of lower portion of F 57342).

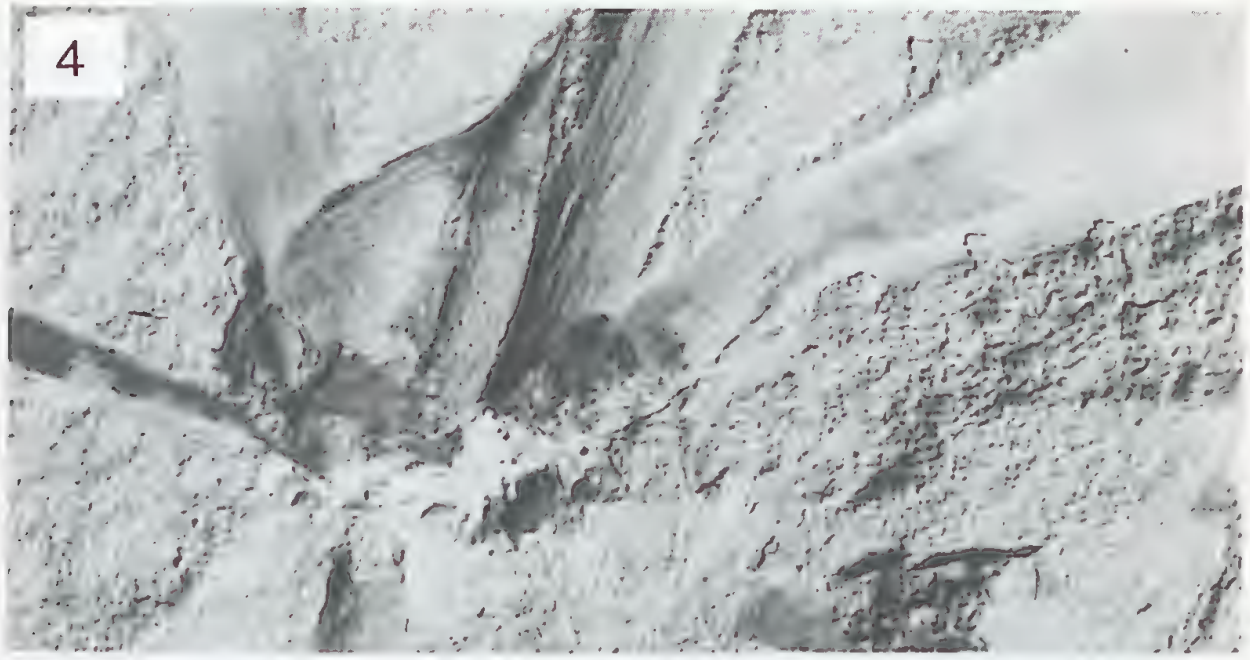
On specimen F 57342 (Figure 3) is a whorl of leaves of *Glossopteris linearis* McCoy. In the centre of the whorl is a *Squamella australis* scale in situ (A). This represents the base of a cone. The cone has been broken up into its component parts. Scale-fronds and sporangial masses lie near the leaf whorl (C) associated with gangamopteroid small leaves (B), and forming a dense aggregation on the lower part of the specimen (D). Figure 4 shows an enlargement of the centre of the leaf whorl on the counterpart F 57341.

Paratypes F 57655, 57316, 57645, 57625, 57626, 57659, 57315, 43706, 57667, 46445, 25729, 44461, 43659, 14948. B.M.R. CPC 4369, 4366, 4375, 4363 M.M.F. 18918, 17100.

Specimens F 57655, F 57316 and F 57645, Figurers 5, 6, and 7 show aggregations of scales, sporangial masses and gangamopteroid leaves from broken up cones. In Figure 7 an *Eretmonia* type gangamopteroid leaf lies next to squamae and sporangia (A). It is probably a modification form referable to *S. australis*, intermediate between the squamous scale-fronds of the cone and the gangamopteroid leaves. Laminal segments of scale-fronds are elongated in Figure 5. The implication is that in young cones (as seen in Figures 8 and 9) the cone was compact with scale-fronds with short laminal segments closely overlapping and concealing and protecting the sporangia. In a ripening cone, elongation of the laminal segments allowed the sporangia to hang out. The scales would have been deciduous when the spores were ready to disperse and protection was no longer necessary.

Figures 8 and 9 illustrate specimen F 57625 and counterpart 57626. A segment of bore core from the Elecom Wyong DDH 6 Bore was presented by the Joint Coal Board in 1966. When it was split in 1975 the specimen was revealed. It represents a young cone broken up into its component parts of scale-fronds with short, wide laminal segments and large sporangial clusters containing very numerous sporangia. The squamae are deeply

Fig. 3. Squamella australis (White). Specimen F 57341. Magn. X 1.3. Whorl of leaves of *Glossopteris linearis* McCoy with *Squamella australis* scale-frond at centre (A); gangamopteroid leaves (B); scale-fronds and sporangia from broken cone near whorl (C); and mass of scale-fronds, sporangial clusters and gangamopteroid leaves from broken cone forming dense deposit on lower portion of specimen (D).



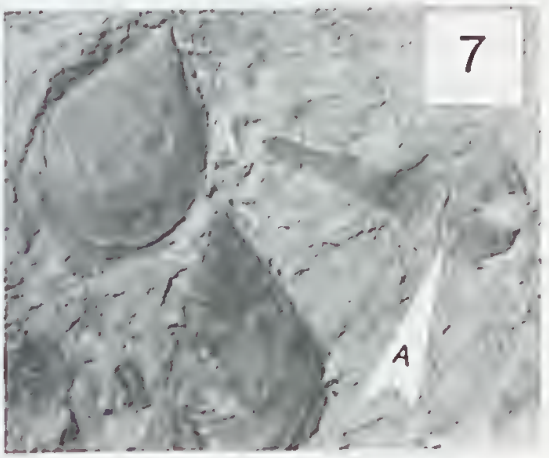


Fig. 4. *Squamella australis* (White). Specimen F 57342. Magn. X 3. Base of cone in situ in centre of whorl of leaves. Fig. 5. Specimen F 57655. Magn. X 1.5. Scale-fronds, sporangial clusters and gangamopteroid small leaves from broken up cone. Fig. 6. Specimen F 57316. Magn. X 2. Gangamopteroid small leaf and scale-fronds. Fig. 7. Specimen F 57645. Magn. X 1.5 Squamae and *Eretmonia* type gangamopteroid leaf (A).

concave. Comparison of this specimen with the B.M.R. specimen CPC 4369 illustrated in Figure 10 shows that *"Lidgettonia australis"* was in fact an example of incomplete or immature *Squamella* scale-fronds with only an indication of where the sporangial masses had been or would be (A, B, C). The interpretation of the fructifications as cupules was incorrect. Figures 10, 12 and 13 show B.M.R. type specimens CPC 4366, 4375 and 4363 which illustrate the serial modification from small leaves to scale-fronds.

Specimen F 57659, Figure 14 shows a scale-frond and sporangial masses on part of a cone axis, and Figure 15 of F 57315 depicts a scale-frond with sporangial cluster at junction of scale and lamina.

The attachment of sporangia to scale-fronds is shown clearly in Figures 16, 17 and 18. Specimen F 43706 (Figs. 16 and 17) shows a concave squama, laminal segment detached, and sporangia borne on forking threads on the line where scale and lamina joined. In F 57667, Fig. 18, there is a sporangial cluster below a squama and one thread is seen attached.

Figure 19 of F 46445 shows a scale-frond in which the apex is indurated. This is an intermediate modification stage.

The nature of complete *Squamella* cones is illustrated in Figures 20 and 21. Of these two Mining Museum specimens illustrated by Walkom (1928) as terminal buds, MMF 18918 is referred to *Squamella* sp. as it is bulkier than those recognised as *S. australis* and the scales are not typical. It is of particular interest, however, as it shows what is believed to be an aggregation of sporangia at the base of a scale on the side of the specimen. Figure 20A illustrates this feature. Specimen MMF 17100 shows a finer, smaller cone with scales of the sort identified as *S. australis*.

There are no *Squamella* cones in the Australian Museum Collection as complete as those illustrated from the Mining Museum. However, F 25729, Figure 22, shows part of a cone with a number of overlapping scales and F 44461, Figure 23, shows a cone apex. In specimen F 43659, Figure 24, is a cone axis from which scale-fronds have fallen, and a similar axis is seen in Figure 25 of F 14948. Both axes have absciss scars of scale-fronds and impressions from the sporangial masses which had been adpressed.

Squamella ampla gen. et sp. nov.

DIAGNOSIS: Large cones, length much in excess of the 10 cm sections preserved in the only fairly complete specimen. Cone axis had a diameter of more than 1 cm. Scale-fronds attached to axis in close spiral arrangement. Squamae are broad, shallow and only slightly concave. Laminal segments were approximately three times longer than the scales. Entire scale-fronds were woody in mature cone. Cones referred to *Glossopteris ampla* Dana.

DESCRIPTION OF SPECIMENS: Holotype F 8836. Paratypes F 40459, 28040, 25668, 26063. Associated with very large leaves of *Glossopteris ampla* Dana at a number of localities are broad, shallow squamae, belived to be the scale part of scale-fronds. Figure 27 of specimen F 40459 illustrates one of these squamae. A complete scale-frond in which the squamae and laminal segment are still attached is seen in Figure 28 of F 28040. A woody laminal segment of a scale-frond from which the squama has fallen is shown in Figure 29 of F 25668.

Specimen F 8836, designated the holotype for *Squamella ampla*, is illustrated in Figure 30. It shows a number of woody scale-fronds composed of shallow squamae and broad laminal segments, overlapping in ascending spiral formation. They have obviously

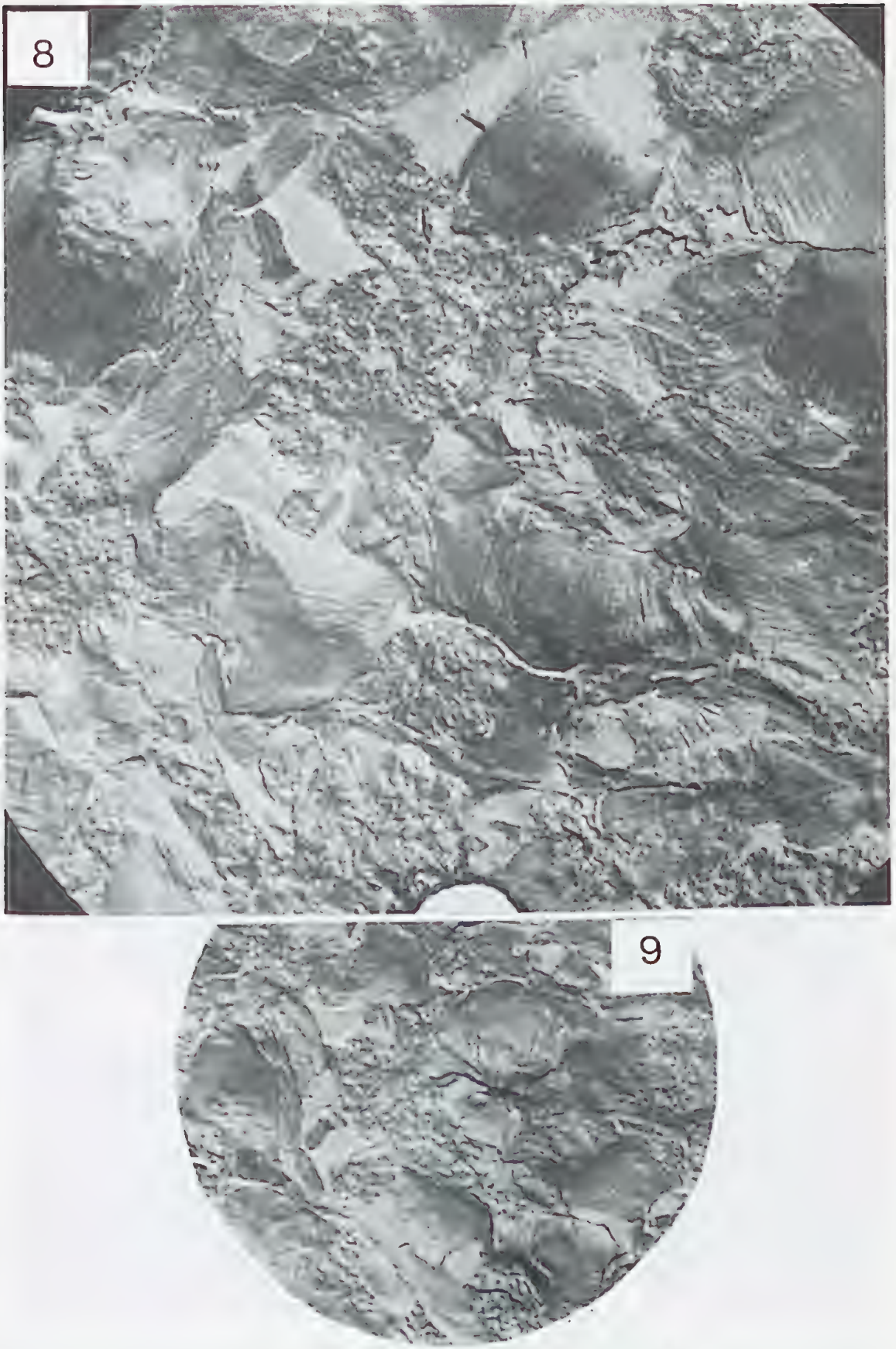
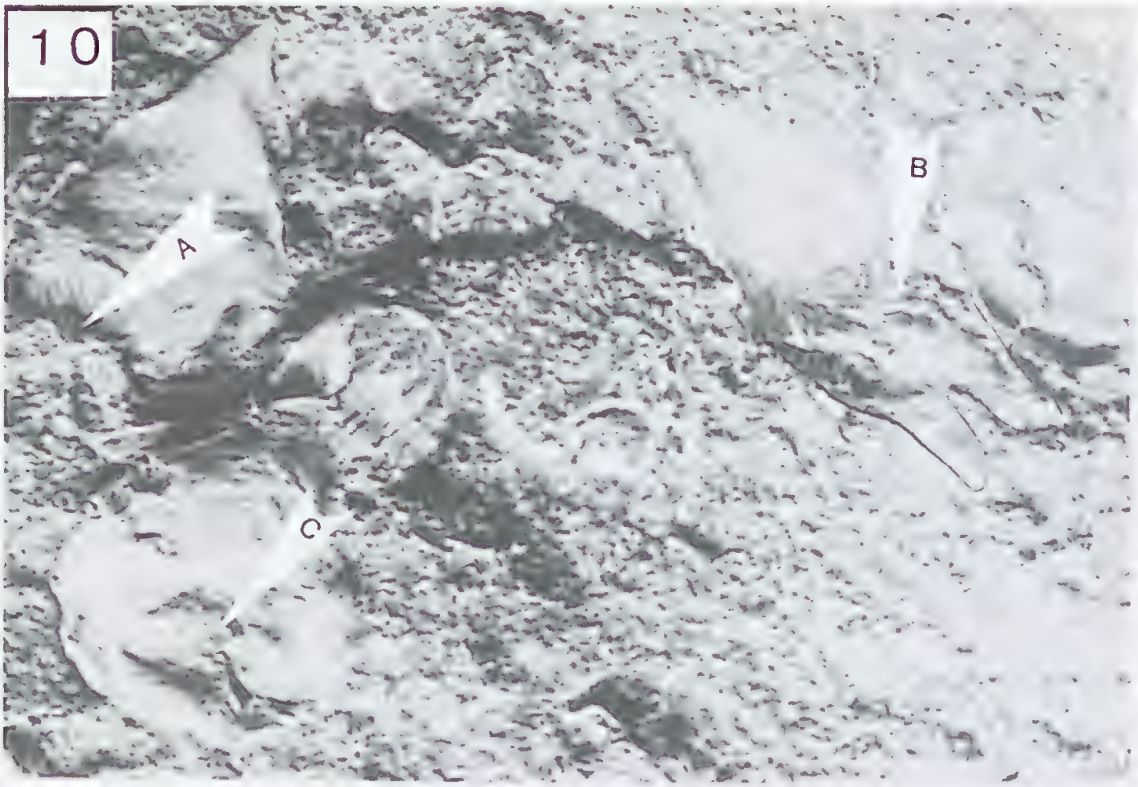
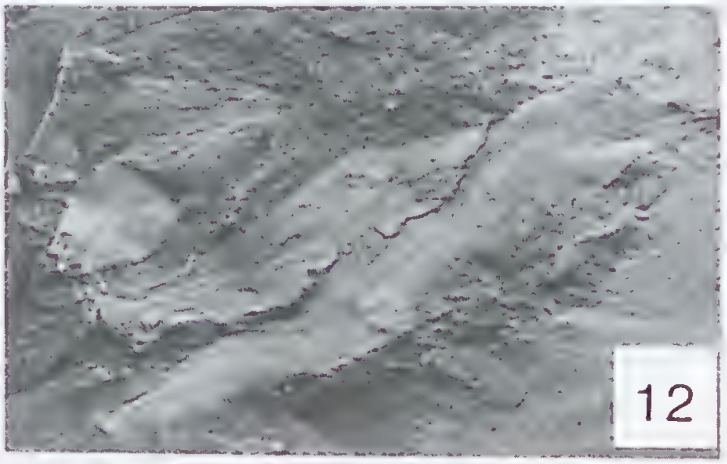


Fig. 8. *Squamella australis* (White). Specimen F 57625. Magn. X 3. Scale-fronds and sporangial clusters from broken up cone. Fig. 9. Specimen F 57626. Magn. X 1.5. Part of counterpart of Figure 8.





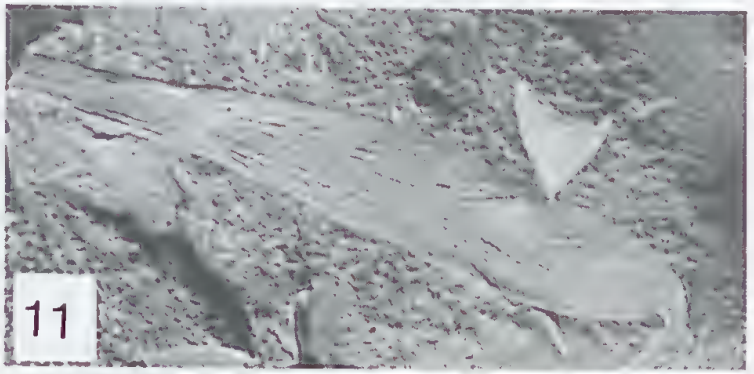
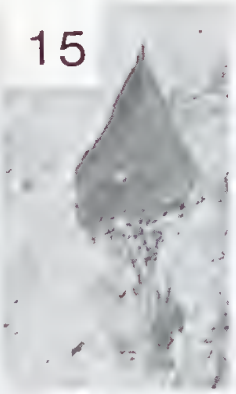
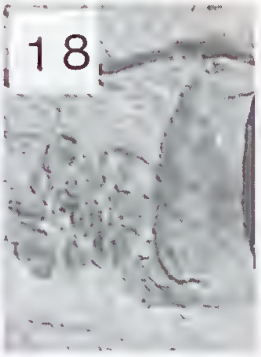
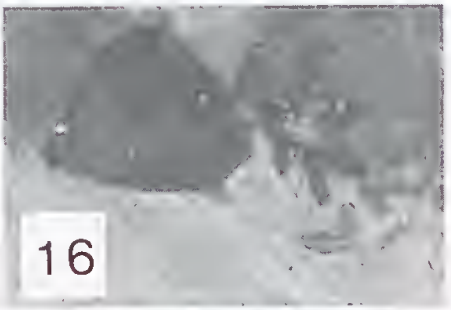
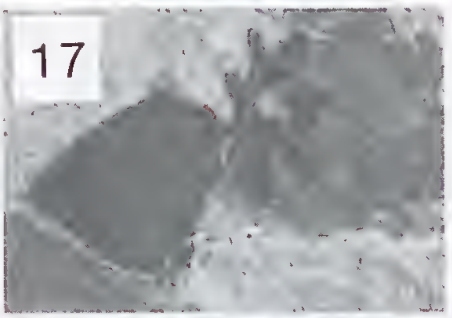


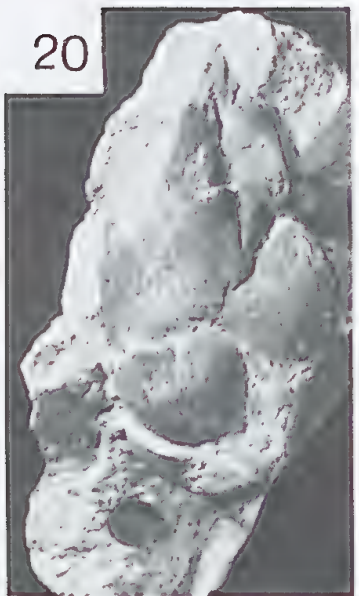
Fig. 10. *"Lidgettonia australis* White." Specimen B.M.R. C.P.C. 4369. Magn. X 4. Scale-fronds with fructifications attached at (A), (B), (C). Fig. 11. Specimen B.M.R. C.P.C. 4366. Magn. X 2. Gangamopteroid small leaf, concave squama. Fig. 12. Specimen B.M.R. C.P.C. 4375. Magn. X 2. Gangamopteroid small leaves with indurated tips. Fig. 13. Specimen B.M.R. C.P.C. 4363. Magn. X 4. Scale-frond of long, gangamopteroid lamina with small scale attached.

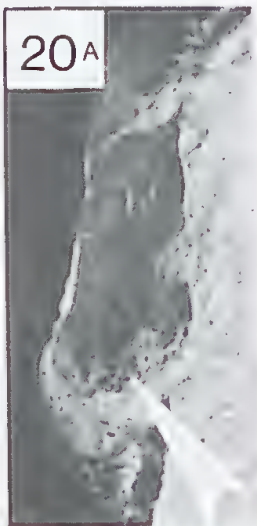












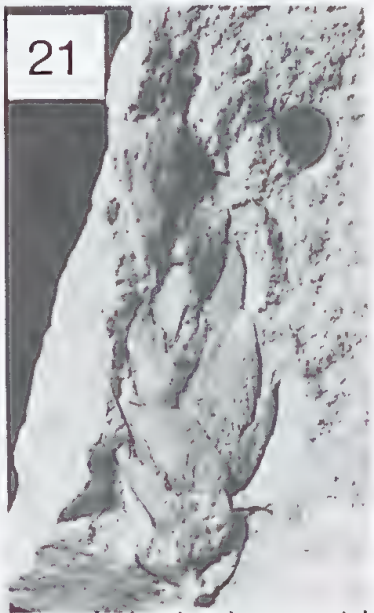
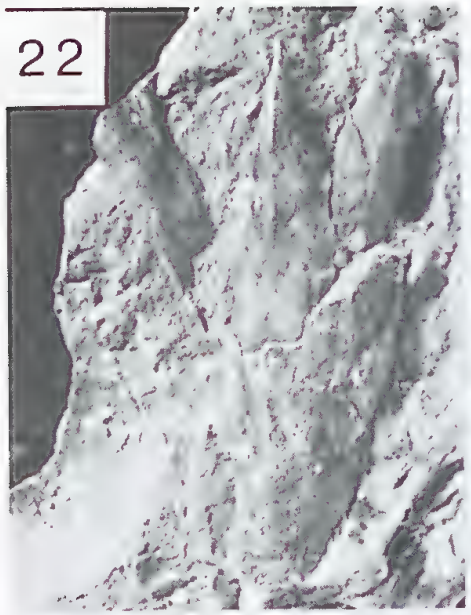
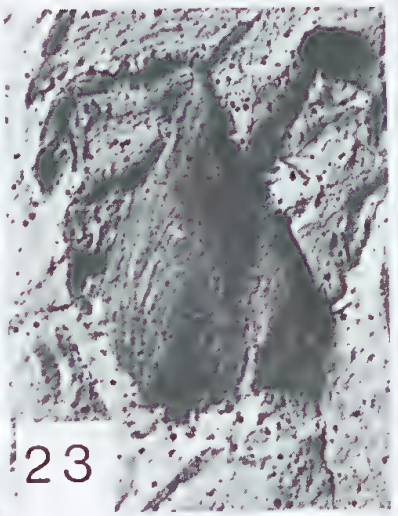
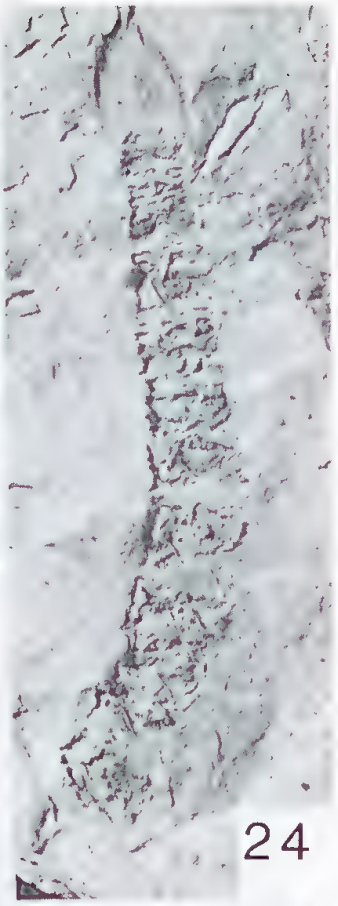
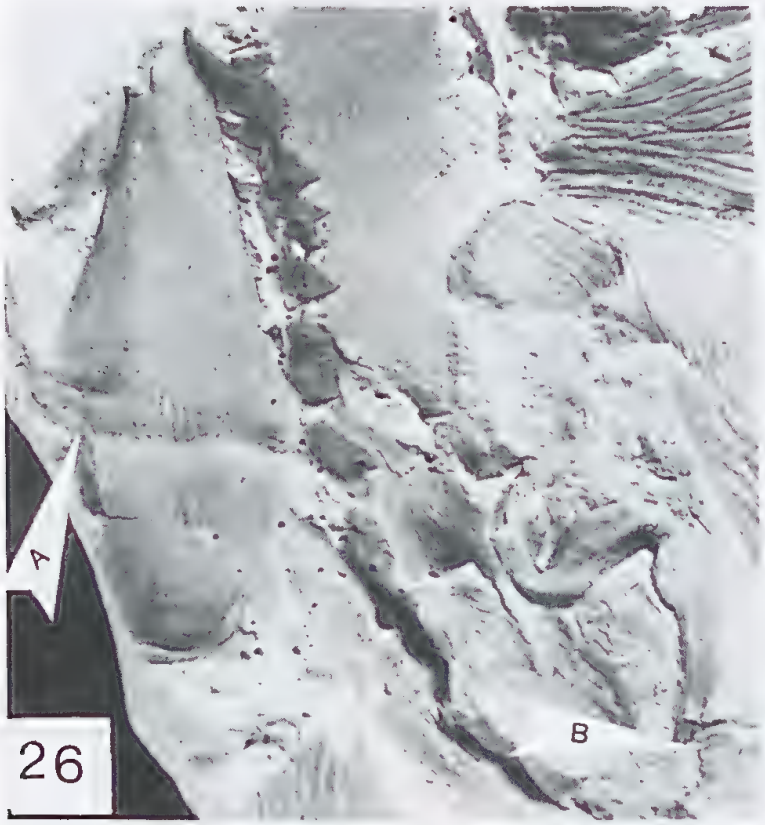


Fig. 14. *Squamella australis* (White). Specimen F 57659. Magn. X 3. Scale-fond and sporangial clusters (arrowed) on part of cone axis. Fig. 15. Specimen F 57315. Magn. X 1.5. Scale-frond with sporangial mass at junction of squama and laminal segment. Figs. 16-17. Specimen F 43706. Magn. X 4. Squama without laminal segment; sporangia borne on forking threads attached on line of junction with lamina. Fig. 18. Specimen F 57667. Magn. X 4. Sporangial mass attached to junction of lamina and squama. Fig. 19. Specimen F 47445. Magn. X 1. Gangamopteroid small leaf with indurated tip. Intermediate between gangamopteroid leaf and scale-frond. Fig. 20. Specimen MF 18918. Magn. X 1. *Squamella* sp., complete cone. "Terminal bud" of Walkom 1928. Fig. 20A. Specimen MF18918. Magn. X 2. Cone viewed from the side. Sporangia at arrow. Fig. 21. Specimen MF 17100. Magn. X 1. Complete *Squamella australis* cone.









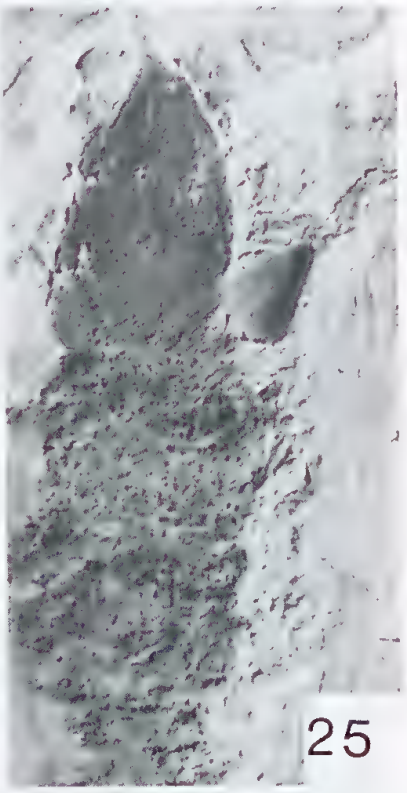


Fig. 22. *Squamella australis* (White). Specimen F 25729. Magn. X 2. Cone. Fig 23. Specimen F 44461. Magn. X 2. Apex of cone of *Squamella australis*. Fig. 24. F 43659. Magn. X 2. Axix of Cone. Fig. 25. Specimen F 14948. Magn. X 3. Axis of cone. Fig. 26. *Squamella ovulifera* (White). Specimen F 26227. Magn. X 2. Pointed squama of scale-frond attached to short laminal segment. Pedicel attached at (A) on line of junction of scale and lamina. Separate fleshy pedicel with seed (B), gangamopteriod leaves in centre of specimen.

been disarranged from a cone. Part of a leaf of *Glossopteris ampla* lies below the scale-fronds. *Glossopteris ampla* is used in a narrow sense, comprising only the large leaves, which in some cases must have been half a metre in length, which are associated with the scale fronds and squamae described above.

Etheridge (1904) described a specimen F 26063 as a caudex of *Glossopteris*. This specimen, illustrated in Figure 31 of this paper, shows what Etheridge described as leaf base scars in ascending spiral formation. The scars can now be seen to be the squamae of scale-fronds of *Squamella ampla* and the specimen represents a cone, not a caudex. The oval (compressed cylinder) core of the specimen can be seen at one end of the specimen. The cone scales, or scale-fronds, are seen to be displaced from one side of the core, a feature substantiating the nature of the organ. Specimen F 8836 (Figure 30) in which only a few scale-fronds of the cone are preserved, could not be confused with a caudex. The evidence of separate squamae, laminal segments and compound structure of scale-frond as illustrated in Figures 27-29 confirms the diagnosis of specimen F 26063 as *Squamella ampla*.

A diagrammatic representation of *Squamella ampla* is seen in Figure 32.

Squamella ovulifera gen. et sp. nov.

DIAGNOSIS: Holotype F 26227. Cones in which scale-fronds were acutely pointed. The laminal segment was short, about half the length of the squama, and seeds were borne on fleshy pedicels attached at junction of scale and lamina.

DESCRIPTION OF SPECIMEN: In specimen F 26227, illustrated in Figure 26, a pointed scale is seen in attachment to a short, broad laminal segment. A pedicel is attached laterally at the point of junction of scale and lamina (A). A seed (B) is attached to a long, fleshy pedicel above, and there is a small, modified, gangamopteroid leaf present. There are many of these pointed scales free in material from Late Permian strata at Newcastle and elsewhere, and it seems likely that they were aggregated into cones as in *Squamella australis* and *Squamella ampla*.

They were female cones and the name *ovulifera* is appropriate.

In Lacey et al. 1975, p. 406, specimen MN 1419 shows a scale-frond which appears to have the squama indurated and a line of seeds attached at junction of the scale and laminal segment. This may be a female *Squamella* scale-frond which has sessile seeds.

PART II: *GLOSSOPTERIS LINEARIS* McCOY

INTERNAL STRUCTURE OF STEM

Specimen F 48156, Figure 33, was described by Etheridge (1894) as a rare example of *Glossopteris* leaves in attachment to a stem. He was under the impression that no internal structure had been preserved in the stem, part of which is fossilised as a solid cylinder. A transverse section of the stem (at arrow) was found to have some preservation of cell structure. Figure 34 shows the arrangement of tissues in the stem.

There is a central core of primary xylem, or xylem and pith (A) surrounded by a uniform zone of secondary xylem composed of small-diameter tracheids in very regular rows (B). A dark zone of tissue representing the phloem and cambium follow (C), and the outer region is composed of leaf bases. Vascular bundles can be seen in some of the leaf bases, but preservation is poor.

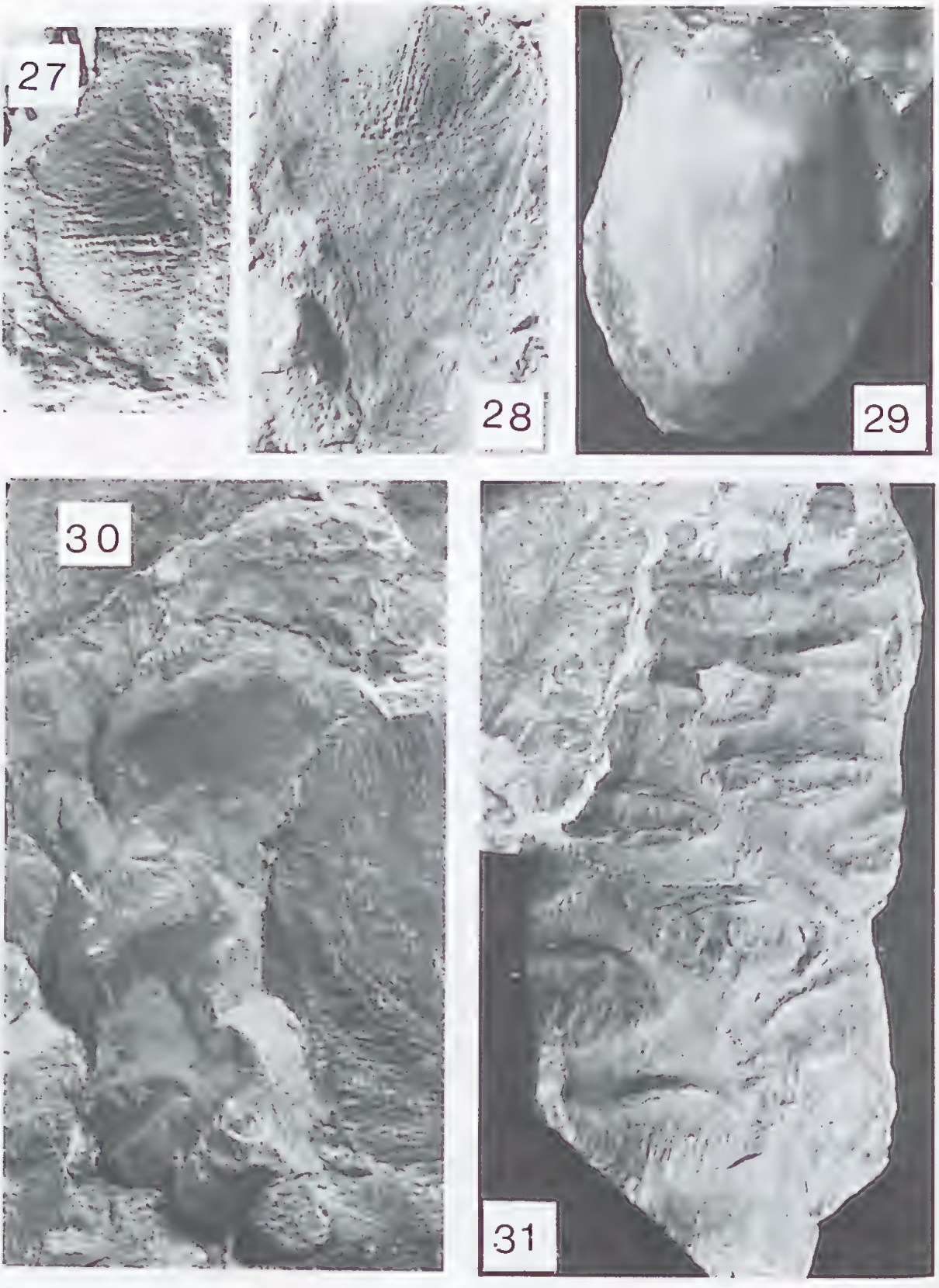


Fig. 27 *Squamella ampla* White. Specimen F 40459. Magn. X 2. Shallow, concave scale, detached from laminal section of scale-frond. Fig. 28. Specimen F 28040. Magn. X 2. Complete scale-frond with squama and laminal segment united. Fig. 29. Specimen F 25668. Magn. X 2. Laminal segment of scale-frond. Fig. 30. Specimen F 8836. Magn. X 1.5. Overlapping scale-fronds of mature cone. Lamina and squama obviously substantial and woody. Venation of *Glossopteris ampla* Dana to the right of the cone scales. Fig. 31. Specimen F 26063. Magn. X 1.5. Portion of cone. Squamae of scale-fronds in ascending spiral.

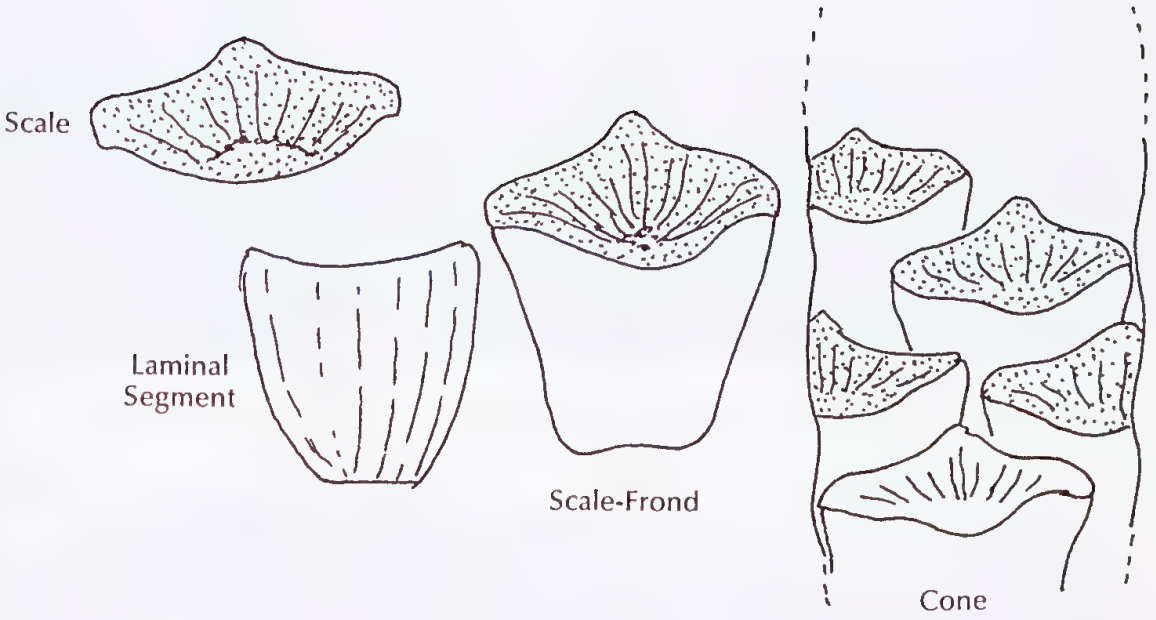


Fig. 32. Diagrammatic representation of *Squamella ampla*. Scale-fronds composed of shallow, woody squama, elongated laminal segment, arranged in ascending spiral on axis to form a cone.

Leaf bases can be seen to the right of the arrow in Figure 33 in impression, and on the outside of the petrified cast to the left of the arrow. The leaves appear to have been sessile with an absciss layer. Whether or not this leaf-bearing branchlet is a short shoot, is not indicated in the specimen.

DESCRIPTION OF *GLOSSOPTERIS LINEARIS* AS GIVEN BY McCOY, 1847.

"S. char.: Leaves very long, narrow, with nearly parallel sides: Midrib very large, secondary veins fine, forming an angle of about 50° with the midrib, anastomosing occasionally from the midrib to the margin.

It is only with *Glossopteris angustifolia* Bgt. from the Indian coal fields of Rana-Gunge, near Rajemahl, that this long, parallel-sided frond could be confounded and it is distinguished easily from that species by the fineness of the neuration which is as remarkably delicate as that of the other is coarse; the neuration of *G. angustifolia* is also distinguished by its great obliquity, forming an angle of about 30° with the midrib, while the nerving of the present species is not more oblique than that of *G. browniana* or *G. nilssoniana*. In this species also, from the anastomosing being continued up to the margin, it results that the nerves are little closer at the margin than in the middle of the leaf, while in *G. angustifolia* the anastomosing is confined to the central portion, and the dichotomising goes on to the margin, where in consequence the neuration is finer and closer than towards the midrib."

DESCRIPTION OF *GLOSSSOPTERIS LINEARIS* McCOY AS A WHOLE PLANT.

McCoy (1847) described detached leaves of the species. Additional information is now available on the structure and appearance of the plant which bore the leaves.

Glossopteris linearis McCoy was a woody plant with gymnospermous internal structure. It bore its linear-lanceolate leaves in whorls or close spiral arrangement on branchlets which were substantial, with considerable development of secondary wood. The leaves were deciduous, and were borne sessile on the stem with an absciss layer from which they fell, leaving a small cushion of tissue which formed an ornamentation on the outside of the stem.

The male reproductive phase of the plant comprised cones which terminated leaf-bearing branchlets. A whorl of modified, gangamopteroid, small leaves preceded the cone, between it and the normal foliage leaves. Cones were aggregations of scale-fronds, each consisting of a squama and a laminal segment. The squamae were deciduous. On the line of junction between squama and laminal segment in each scale-frond, clusters of sporangia of *Arberiella* type were attached. The sporangia were borne on fine, branching threads.

In the young male cones the scale-fronds were closely packed and had short laminal segments, and the sporangial masses were protected by the overlapping squamae. Ripening was accompanied by elongation of laminal segments, resulting in a lax cone with easy spore distribution even before the squamae fell off.

The female phase of the plant is unknown.

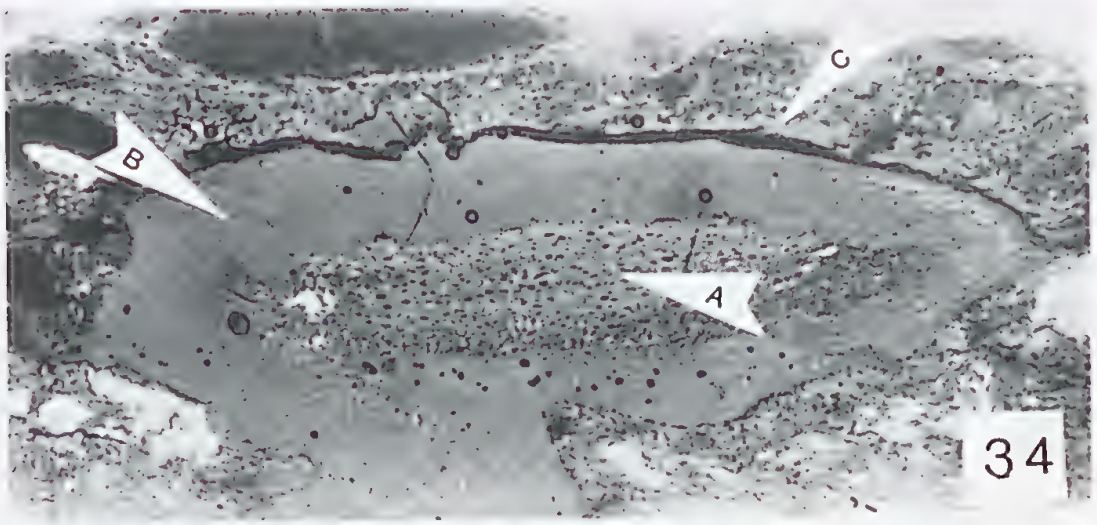


Fig. 33. *Glossopteris linearis* McCoy. Specimen F 48156. Magn. X .5. Whorl of leaves of *Glossopteris linearis* McCoy attached to top of a branchlet. Leaf base ornamentation of stem, which is petrified as a flattened cylinder with some cell preservation to the left of the arrow, and seen in impression to the right. Fig. 34. Specimen F 48156. Tranverse section of stem, magn. approx. X 20 showing central region (A) of primary xylem or xylem and pith, regular tracheids of secondary xylem (B) and dark-stained cambial and phloeum layer (C). Leaf bases form outer regions.

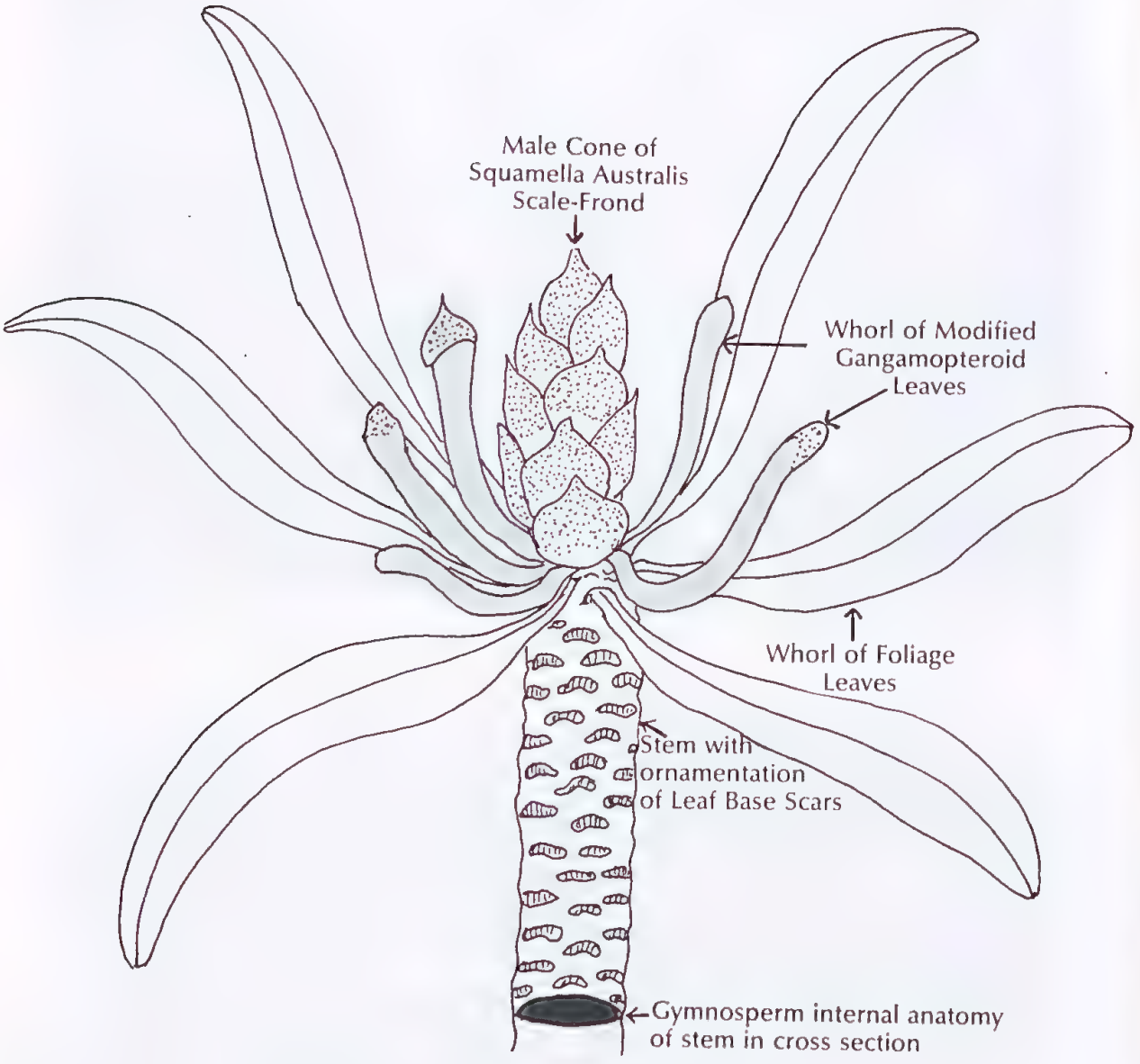


Fig. 35. Diagrammatic representation of *Glossopteris linearis* McCoy.

PART III: GENUS *PARTHA* SURANGE & CHANDRA 1973

Surange and Maheshwari (1970) described a new glossopteridalean fructification as *Lidgettonia indica*. Surange and Chandra (1973) erected the genus *Partha* which is described as being a fertile "scale" which is oval-spathulate in shape, has gangamopteroid venation and bears four pedicels. They incorporated *Lidgettonia indica* in *Partha*. The pedicels were attached to the mid-vein in the stalk region of the fertile leaf, and each bore four seeds or single-seeded cupules.

(a). **Partha belmontensis** sp. nov.

DIAGNOSIS: Small gangamopteroid leaves 3 cm long, spathulate in form with a maximum width of 0.5 cm near the top of the lamina. Apex rounded. Venation of three or four strands in the centre of the lamina, reticulation towards margins. Lower third of lamina narrowed into a stalk. Pairs of pedicels on each side of median line of lamina, each forking and bearing two single-seeded cupules, attached where the lamina narrows into a stalk.

DESCRIPTION OF SPECIMENS: Holotype: F 46525, Paratypes: F 39925, 41095, 57391. F 46525, illustrated in Figures 36 and 37, was collected from the Insect Horizon (Late Permian) at Belmont, N.S.W. It is excellently preserved and shows a small gangamopteroid leaf 3 cm long with a stranded midrib and reticulated lamina. It bears seeds, or single-seeded cupules, which are oval in outline, 0.5 cm long and 0.4 cm maximum width. These seeds are borne in pairs on branchlets attached near the midline of the leaf, apparently two branches on each side. It is referable to *Partha* and is the holotype for a new species which is named *belmontensis* after the locality from which it was collected. The Insect Horizon at Belmont (Lake Macquarie) is a well known stratigraphical unit and its insect fossils of Late Permian age have been reported on by Riek (1953).

Detached seeds or cupules which may be referable to *Partha belmontensis* are illustrated in Figures 38, 39 and 40 of specimens F 39925, 41095 and 57391.

(b). **Partha sessilis** sp. nov.

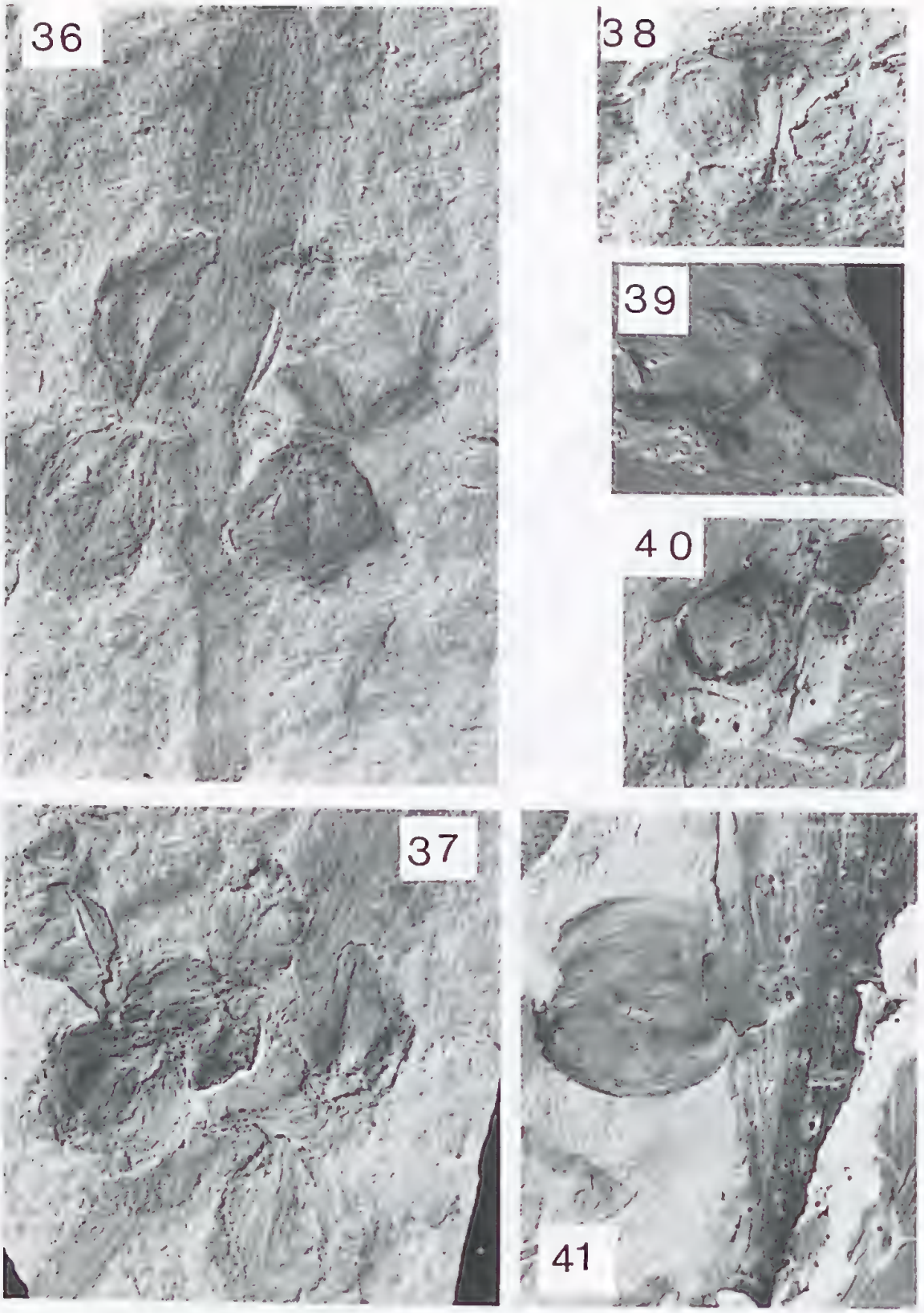
DIAGNOSIS: Gangamopteroid small leaves bearing seeds or single-seeded cupules singly on the leaf margin. The small leaves are similar to those in *Partha belmontensis*.

DESCRIPTION OF SPECIMENS: Holotype: F 29741. F 29741 (Figure 41) shows the base of a gangamopteroid leaf with a sessile seed clearly attached to its margin. A similar leaf base fragment with seed attached to the margin was described and illustrated by White (1965, Plate 5, Fig. 5) in a Bureau of Mineral Resources collection from Agate Creek Volcanics, Queensland.

Partha sessilis is particularly interesting in view of Endrody-Kovaks (1974) description of Glossopteris leaves bearing seeds sessile on the midrib.

(c). **Rusangea elegans** Lacey et al. 1975

Lacey et al. 1975 describes gangamopteroid fertile leaves in which seeds or cupules are borne on scale-like projections attached to the leaf margins. The attachment of the seeds to a scale and not directly to the leaf margin differentiates this species from *Partha sessilis*.



Figs. 36-37. *Partha belmontensis* sp. nov. Specimen F 46525. Magn. X 3. Small, gangamopteroid leaf bearing forking pedicels with pairs of single-seeded cupules. Fig. 38, 39, 40. Specimens F 39925, 41095 and 57391. Magn. X 3. Detached cupules of *Partha belmontensis*. Fig. 41. Specimen F 29741. Magn. X 3. *Partha sessilis* White. Seed attached to margin of small, gangamopteroid leaf.

Specimen F 57663 (Figure 42) is tentatively determined as *Rusangea elegans* Lacey et al. This is a scale-like gangamopteroid leaf and at the base on either side are depressions which could represent scales or seeds.

Specimen F 41109 (Figure 43) illustrates a scale with a pair of seeds attached to the median vein. This is similar to specimens described by Lacey et al. from South Africa. Its affinities are not known.

PART IV: GENUS *ERETMONIA* DU TOIT 1932

Eretmonia natalensis (du Toit) emend. Lacey et al. 1975.

Du Toit (1932) described small, spoon-shaped leaves with sporangial clusters as *Eretmonia natalensis*. Much additional information on the species has been supplied by investigations in recent years. Lacey et al. 1975 give an emended diagnosis of the genus and the species after analysis of all the evidence. Great variation is shown to exist within the species and the three additional species described by Surange and Maheshwari (1970) are within the range and are therefore discarded. Sporangia are borne in two pedicillate clusters, one on either side of the stalk near the point of expansion of the lamina.

Figures 45-49 illustrate examples of *Eretmonia natalensis* in the Australian Museum Collection.

Specimens F 39934 and F 57657 (Figures 45 and 46) show spoon-shaped leaves with sporangial clusters. F 41553 (Figure 47) shows a leaf in which the scale-like lamina is elongated into a stalk and two sporangial clusters lie to one side. F 57624 (Figure 48) shows the petiolar region on an *Eretmonia* leaf with a sporangial cluster attached to one side, another broken up above. This specimen looks like the reconstruction of *Eretmonia cooyalensis* Holmes 1974 but re-examination of Holmes' type specimen F 55031 shows it in fact to be a poorly preserved specimen of *Partha* sp. (probably *P. indica)*. The pedicels bear seeds and not sporangial clusters. The free sporangial cluster in F 55032 which Holmes interpreted as being the fructification of *"Eretmonia cooyalensis"* is referable to *Eretmonia natalensis* (du Toit) Lacey et al.

Specimen F 57662 (Figure 49) shows a forking pedicel bearing sporangial clusters.

Eretmonia sp.

Specimens F 57658 and F 57661 (Figures 50 and 51) show two examples of fertile leaves bearing pedicillate sporangial clusters. They may fall within the range accepted by Lacey et al. as *Eretmonia natalensis* or may represent a separate species.

PART V: GENUS *LIDGETTONIA* THOMAS 1958

Specimen F 57622, 57623 illustrated in Figures 52 and 53, contains a pointed scale with three peltate discs bearing cupules attached where it narrows into a laminal region. Preservation of the specimen is poor but it appears to be referable to *Lidgettonia*.

PART VI: MULTIOVULATE AND OTHER FRUCTIFICATIONS, NOT BORNE ON MODIFIED SMALL LEAVES OR SCALES

1. *Dictyopteridium sporiferum* (Feist.) Surange and Chandra 1975.

Surange and Chandra (1975) give a full account of the species in its emended form. Much information has been obtained from many authors since Feistmantel first

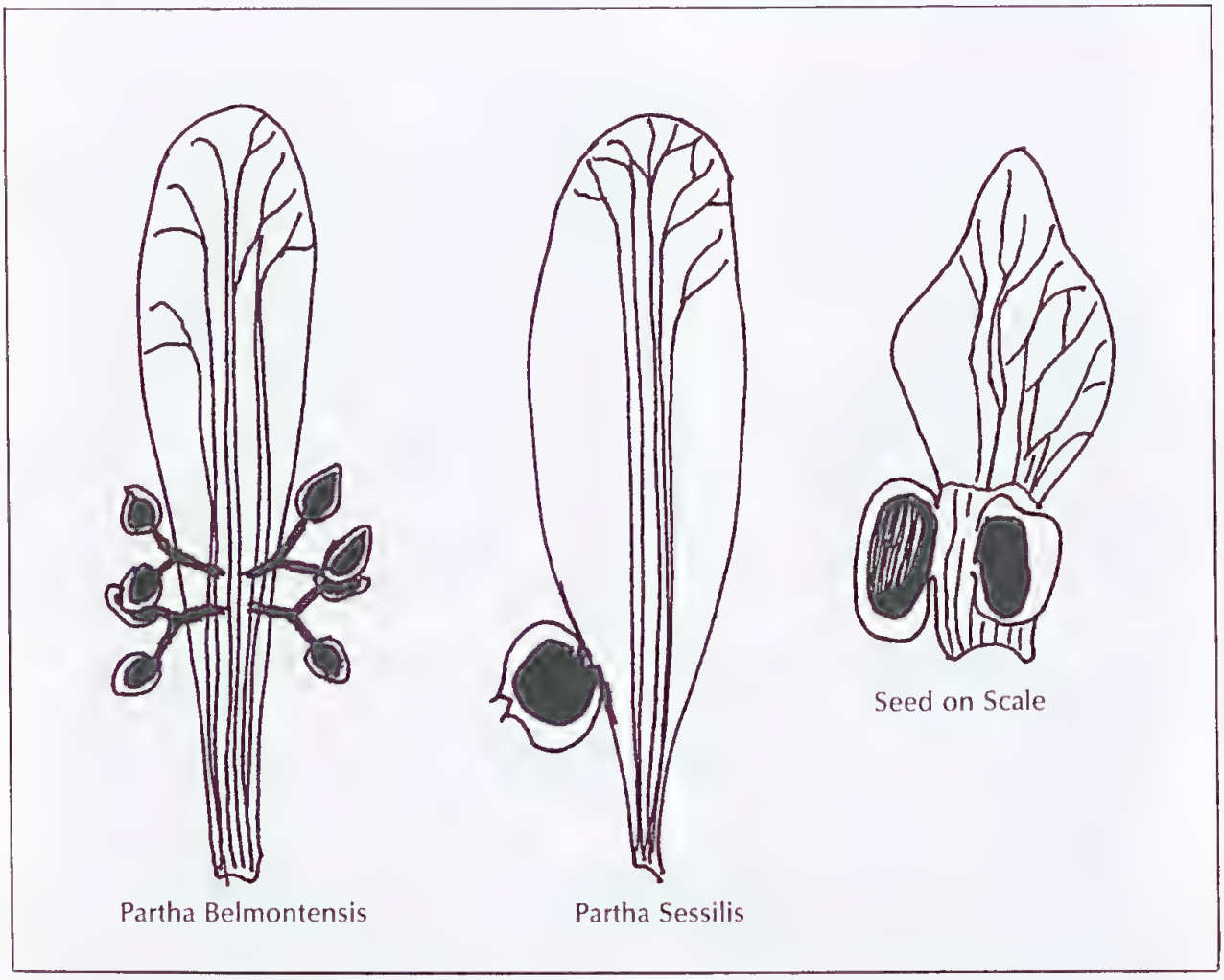


Fig. 44. Diagrammatic representation of *Partha belmontensis, P. sessilis* and *Rusangea elegans*.

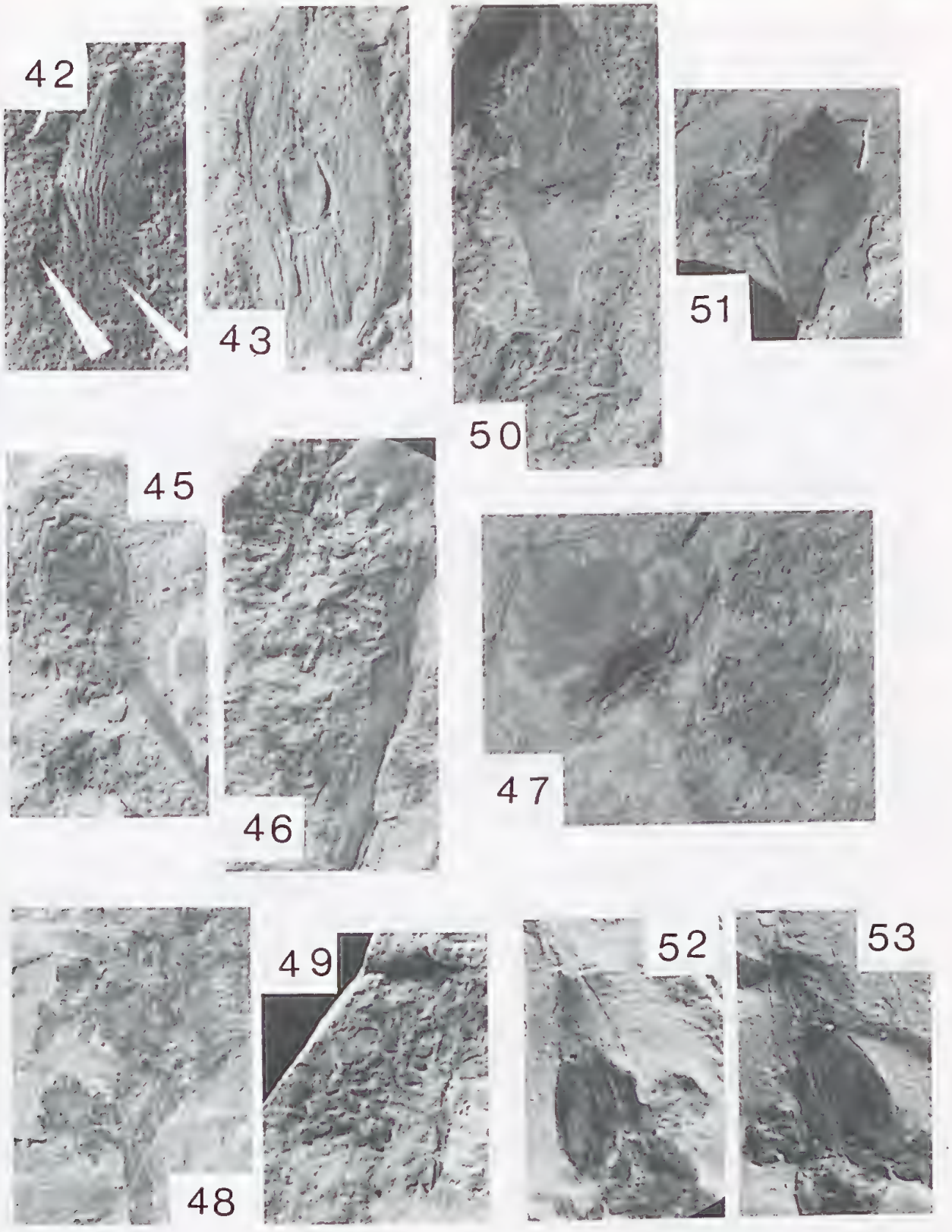


Fig. 42-53 (excluding Fig. 44). *Rusangea, Eretmonia* and *Lidgettonia*. Fig. 42. Specimen F 57663. Magn. X 3. *Rusangea elegans* Lacey et al. Small, gangamopteroid leaf with two depressions at base. Fig. 43. Specimen F 41109. Magn. X 3. Small scale with two seeds attached at midline. Figs. 45 to 49. *Eretmonia natalensis* du Toit. Fig. 45. Specimen F 39934. Magn. X 3. Spoon-shaped gangamopteroid leaf with sporangial cluster attached at point of narrowing into stalk. Fig. 46. Specimen F 57567. Magn. X 3. Fig. 47. Specimen F 41553. Magn. X 3. Fig. 48. Specimen F 57624. Magn. X 3. Fig. 49. Specimen F 57662. Magn. X 3. Forking pedicel bearing sporangial clusters. Figs. 50-51. *Eretmonia* sp. Fig. 50. Specimen F Magn. X 3. Forking pedicel bearing sporangial clusters. Figs. 50-51. *Eretmonia* sp. Fig. 50. Specimen F 57658. Magn. X 3. Scale-like leaf with sporangial clusters at base. Fig. 51. Specimen F 57661. Magn. X 3. Scale-like leaf with sporangial cluster on long stalk. Figs. 52-53. *Lidgettonia* sp. Specimen F 57622, 57623. Magn. X 3. Sharply pointed scale with three stalked cupules attached to midvein of lower portion.

described this species and a full understanding of the structure of the fructification has now been reached.

Dictyopteridium sporiferum is a female reproductive organ which consists of a cylindrical receptacle or axis bearing small ovules on round cushions in close spiral arrangement. The whole ovule-bearing receptacle is naked in the sense that there are no ovuliferous scales or megasporophylls. The receptacle is borne in the axil of a scale leaf, which, being protective, closely fits on one side of the fructification. Understanding the structure of the organ enables interpretation of the different forms seen as fossils.

The commonest form of *Dictyopteridium sporiferum* in the Collection is illustrated by Figure 55 of specimen F 25655. In this the elongated, narrow organ is patterned with small, circular markings from which the seeds have fallen. In Figure 56, specimen F 44074 shows an organ seen from the protective leaf side with the venation of the leaf superimposed on the receptacle and the marginal seeds appearing as a regular, fluted wing. Figure 57 of F 26130 is particularly interesting as it shows long thin seeds in situ along the left margin of the receptacle, and the rest of the receptacle is patterned with small spots from which the seeds have fallen.

Surange and Chandra (1974) include Rigby's 1972 genus *Isodictyopteridium* in *Dictyopteridium sporiferum,* a conclusion justified by evidence in this collection. Holmes (1974) describes as *Isodictyopteridium costatum* sp. nov. examples of *Dictyopteridium* which have a promient midrib (specimens F 55033, 55034). These are examples in which the protective leaf is more evident that usual. The interesting feature of the specimen illustrated by Holmes in Figure 13, Plate 8 (Holmes 1974) is that three leaves occur together and were clearly borne in a whorl.

2. *Scutum* Plumstead, 1958.

Surange and Chandra 1975 explain and clarify the structure of *Scutum.* It is a female reproductive organ which is structurally and functionally gymnospermous. A fertile scale bears a seed-bearing receptacle in its axil, with ovules in close-spiral arrangment. The receptacle and protective scale are borne in the axil of a foliage leaf.

(a). *Scutum sahnii* Surange and Chandra 1975

Figure 58 (F 4219) shows a *Scutum* fructification, seen from the protective leaf side, attached to the base of a leaf of *Glossopteris conspicua* Feist. It is referable to *S. sahnii.* A detached cover leaf of the same appearance occurs in specimen F 25642 and is illustrated in Figure 59.

(b). *Scutum sp.*

A cover leaf from a *Scutum* fructification of a different species is seen in Figure 60 (F 57348).

An incomplete fructification at the base of a *Glossopteris* leaf is illustrated in Figure 61 (F 28183).

Figure 62 (F 57455) shows a small *Scutum* cone enclosed in a protective leaf at the base of a *Glossopteris* leaf.

3. *Ottakaria* Zeiller, 1902.

Zeiller (1902) described a structure consisting of a lobed disc on a slender stalk and believed it to be a vegetative structure. Seward and Sahni (1920) realised it was a fructification. Many authors have added information on its structure in recent years.

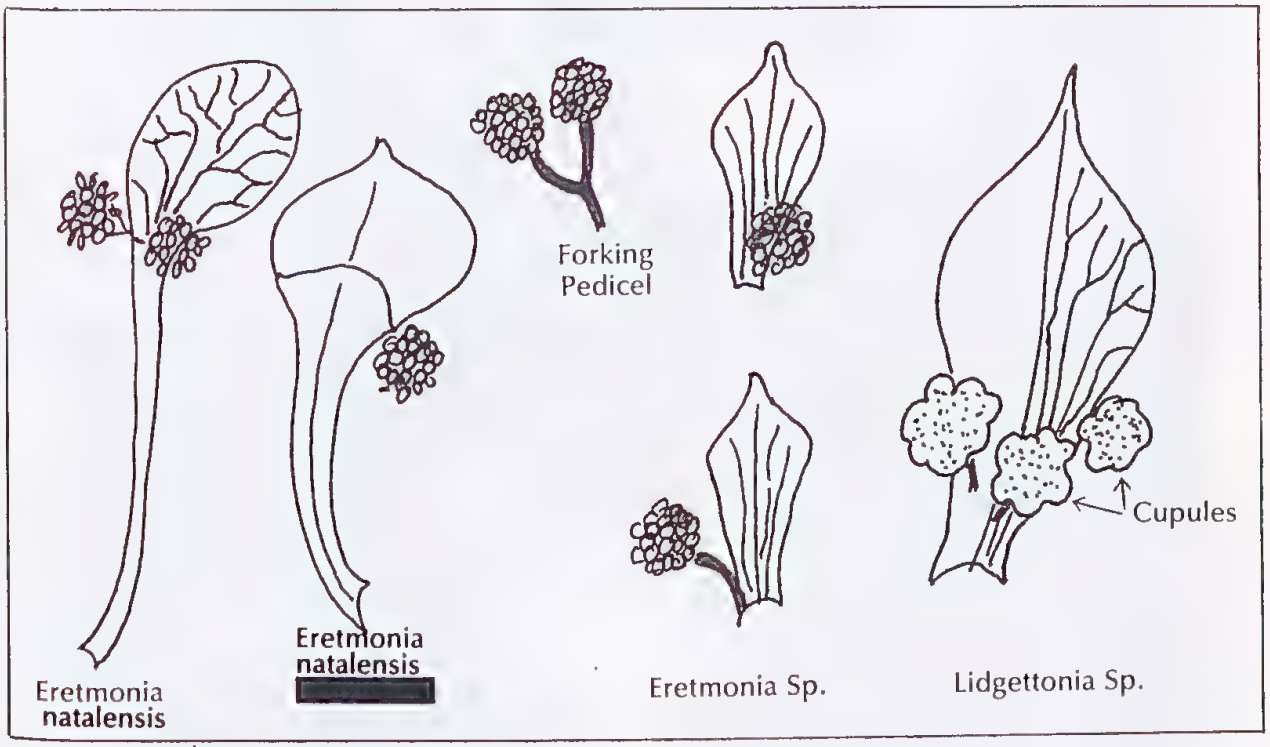
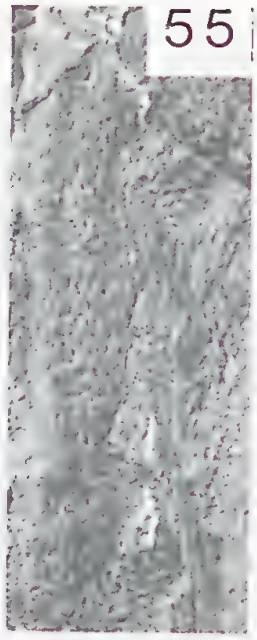
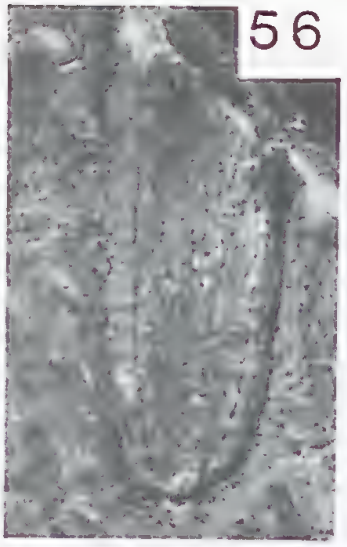
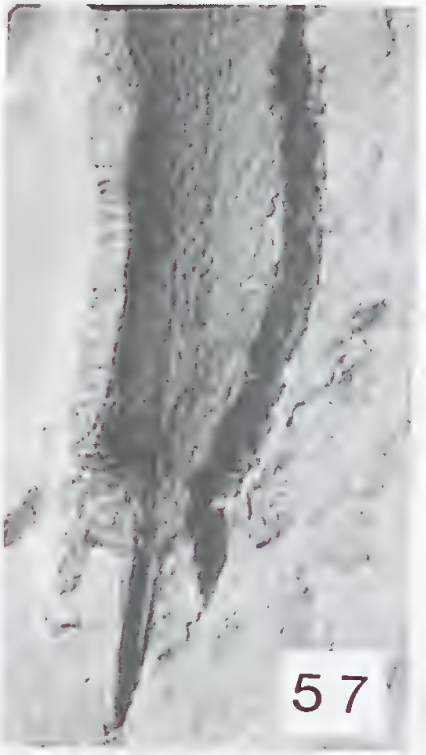
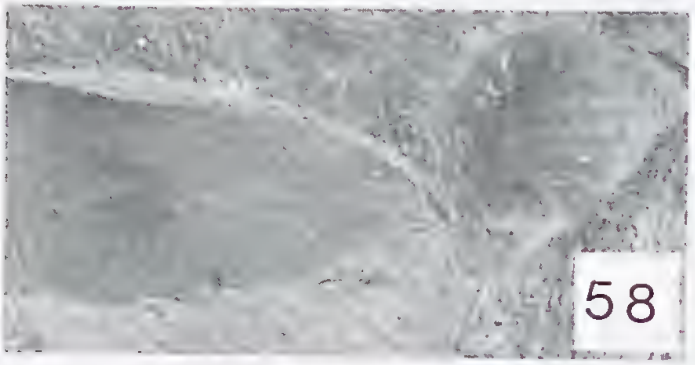


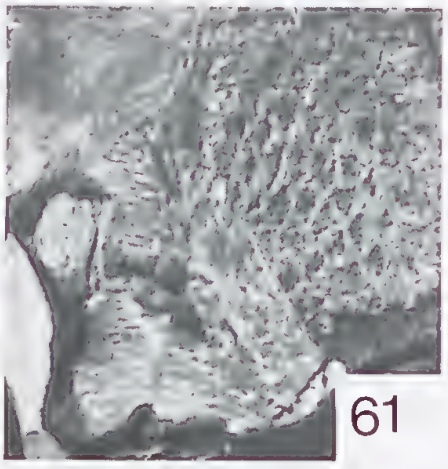
Fig. 54. Diagrammatic representation of *Eretmonia* and *Lidgettonia*.

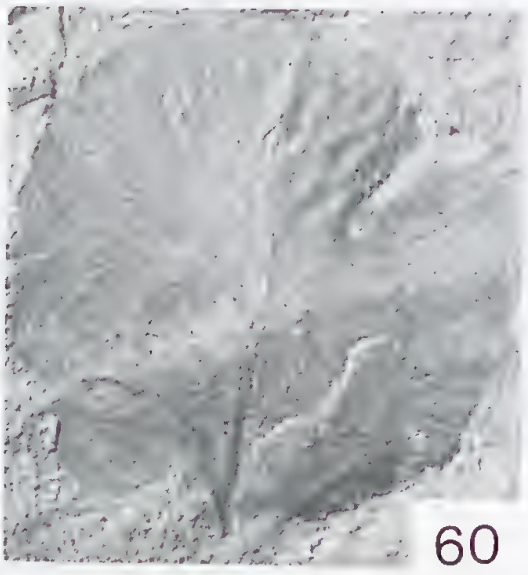


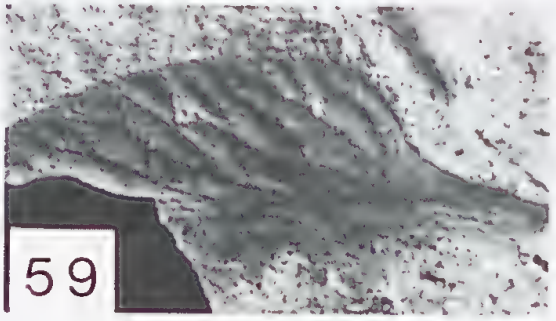












Figs. 55-57. *Dictyopteridium sporiferum* Feist. Fig. 55. Specimen F 25655. Magn. X 1.5. Elongated receptacle with small, circular scars. Fig. 56. Specimen F 44074. Magn. X 1.5. Receptacle covered by protective leaf. Fluted wing effect round outer edge is a line of seeds. Fig. 57. Specimen F 26130. Magn. X .2. Long, narrow seeds in situ along left margin. Receptacle patterned with circular scars from which seeds have been shed. Fig. 58: *Scutum sahnii,* specimen F 4219. Magn. X 1.5. Leaf of *Glossopteris conspicua* Feist with *Scutum* fructification, seen from protective leaf side, attached at base. Fig. 59: *Scutum* protective leaf. Specimen F 25642. Magn. X 2. Fig. 60. Specimen F 57347. Magn. X 3. *Scutum* protective leaf of another species. Fig. 61. *Scutum* sp. Specimen F 28183. Magn. X 1.5. Fructification at base of *Glossopteris* leaf.

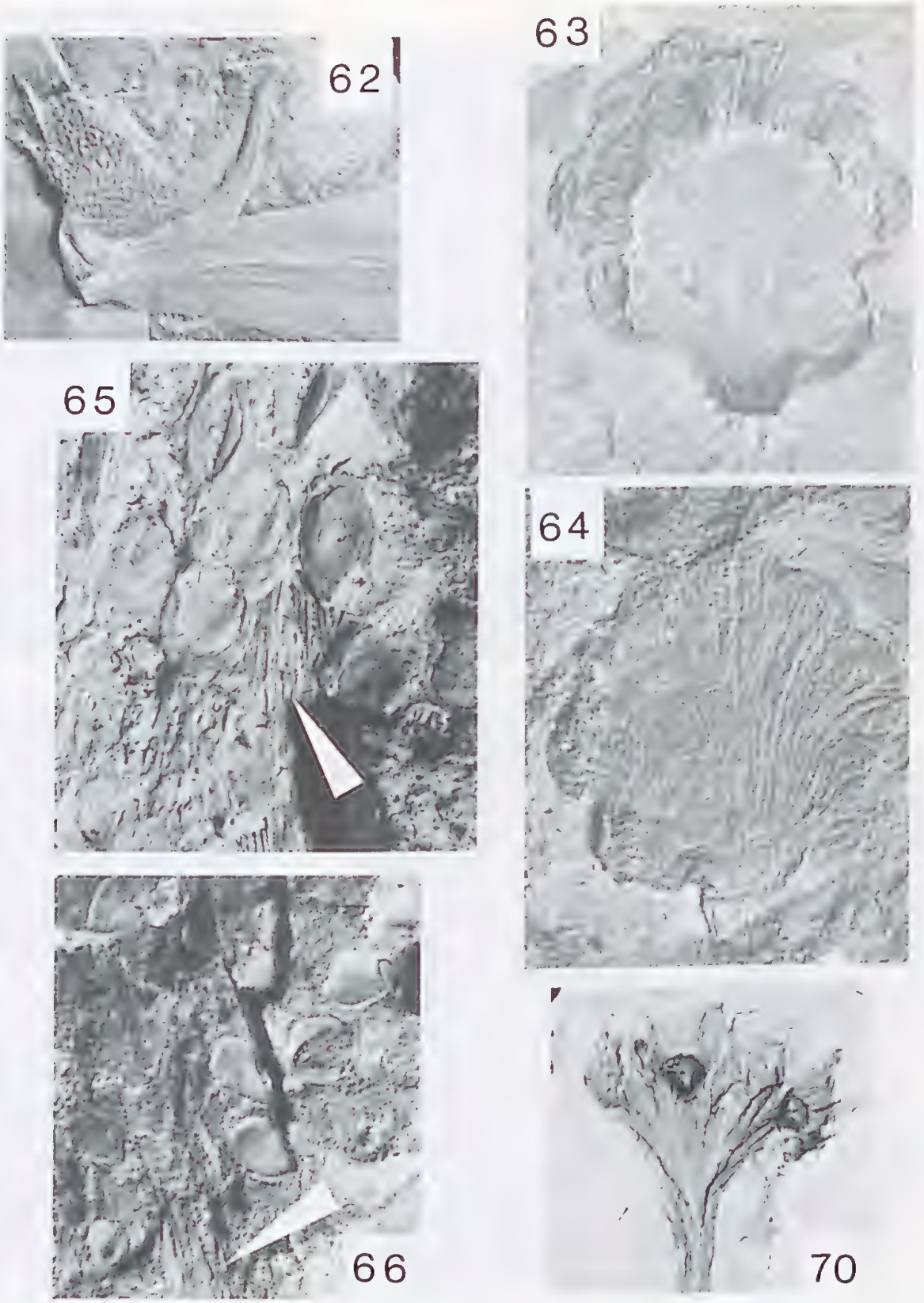
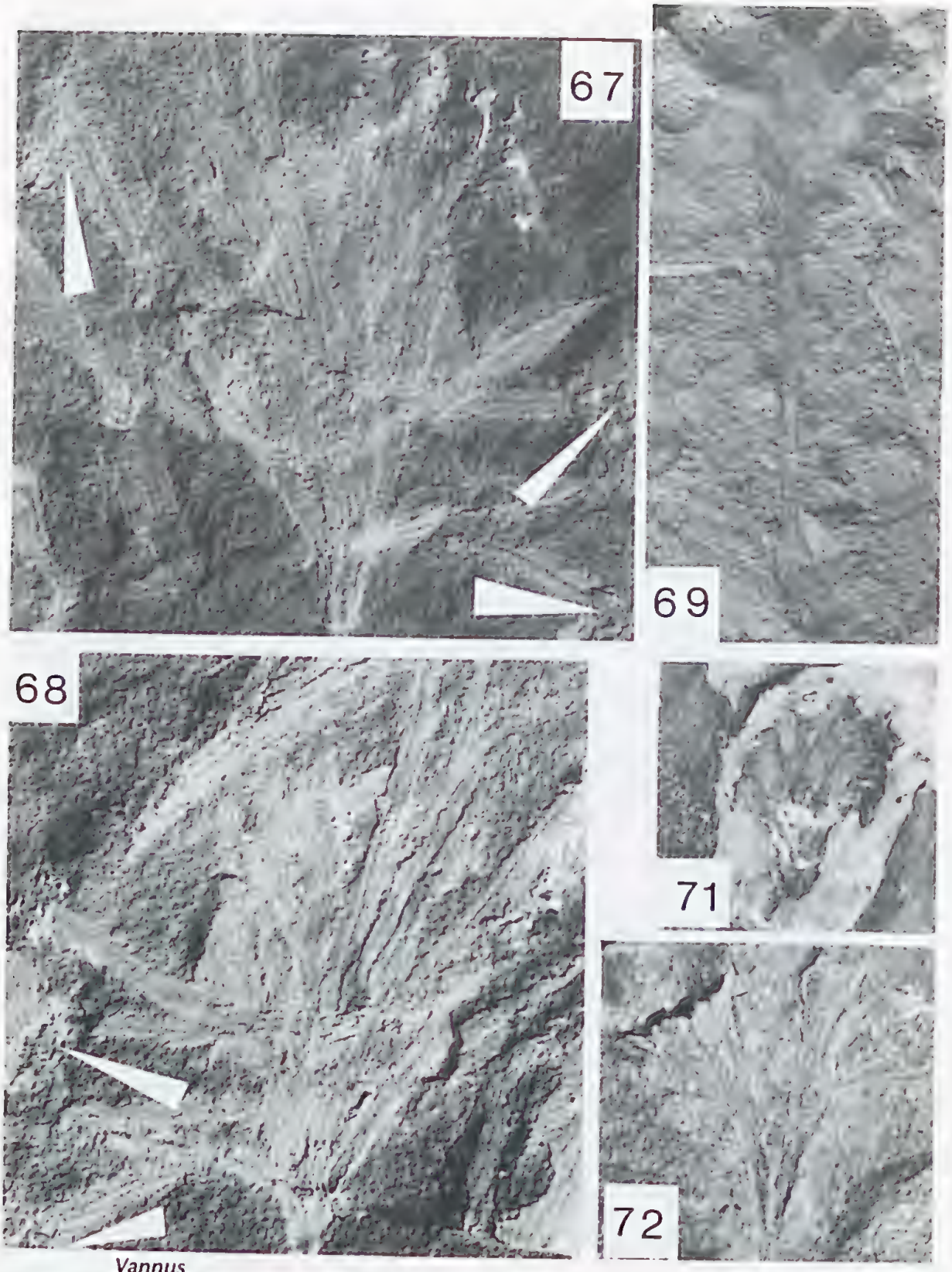


Fig. 62-66, 70. *Scutum, Ottokaria, Cistella* and *Rigbya*. Fig. 62: Specimen F 57485. Magn. X 1.5. *Scutum* fructification inside protective leaf at base of *Glossopteris*. Fig. 63. Specimen F 19713. Magn. X 3. *Ottokaria* fructification in concavity of protective leaf. Fig. 64. Specimen F 19714. Counterpart F 19713. Flat protective leaf which covered *Ottokaria* fructification from other side. Fig. 65. Specimen F 48163. Magn. X 1.5. *Cistella ampla* White. Large seeds in fleshy head on broad stalk (arrowed). Fig. 66. Specimen F 48173. Magn. X 1.5. *Cistella ampla* White. Seeds in head, stalk (arrowed). Fig. 70. Specimen F 57666. Magn. X 2. *Rigbya arberioides*, Lacey et al. Lobed head with seeds attached.



Vannus

Figs. 67-68. Specimen F 57347, 57348. Magn. X 3. Fan of linear bracts with clusters of sporangia (arrowed). Figs. 69, 71, 72. Rigbya arberioides Lacey et al. Fig. 69. Specimen F 29086. Magn. X 2. Lobed head on long stalk. Fig. 71. Specimen F 37390. Magn. X 2. Immature. Fig. 72. Specimen F 57653. Magn. X 2. Bifurcating, lobed head.

Surange and Chandra (1975) summarise the evidence and conclude that it is a multiovulate receptacle borne in the axil of a protective leaf, as in *Scutum*.

Specimen F 19713, 19714 illustrated in Figures 63 and 64 is of particular interest as it shows that the receptacle was in fact covered from both sides. It fitted into a convex protective leaf on one side and was covered from the other by a flat, protective leaf. Both had crenulated margins. The structure is, therefore, considerably different from *Scutum*. If other examples of *Ottokaria* are definitely not organised in this way, it will be necessary to create a new genus for this specimen.

4. *Cistella* Plumstead, 1958

Rigby (1968) states that Plumstead gave the name *Cistella* to some glossopteridalean fructifications in ignorance of the fact that the generic name had already been used. He proposed the name *Plumsteadia* instead of *Cistella*.

Cistella ampla White, 1964

White (1964) described large, fleshy cone-like bodies with seeds clearly embedded in their tissue as *Cistella ampla*. They were associated with *Glossopteris ampla* Dana. They were described as having a smooth integument on one side of the fructification. This feature is in keeping with the protective leaf which is now known to be a feature of *Scutum, Dictyopteridium* and *Cistella* type fructifications.

Two examples of large cones of the species are present in the Australian Museum Collection. F 48163 and F 48173 have large seeds embedded in the matrix of the cones (Figures 65 and 66).

5. *Vannus* Plumstead, 1962

A fructification of uncertain affinities is referred tentatively to the genus *Vannus*.

Specimen F 57347, F 57348 seen in Figures 67 and 68, consists of a whorl or fan-shaped arrangement of linear leaves or bracts arising from a stem apex. The segments each have a median vein. Clusters of sporangia are borne near the apices of some of the bracts (arrowed) and in some areas sporangia can be seen attached singly to the margins of the linear organs. The sporangia are of *Arberiella* type similar to those of *Glossopteris*.

Plumstead describes *Vannus gondwanensis* as a fan of bract-like organs attached to a *Gangamopteris* leaf. No sporangia were detected and the nature of the organ was unknown. Perhaps it was a sporangium-bearing organ and the specimen here described is a *Vannus* and referable to the *Glossopteridales*.

In this connection, *Vojnovskya paradoxa* Neuberg 1955, illustrated by Andrews 1961 (p. 352) is also of interest. This plant has micro- and megasporangial organs arranged in a crown on a short shoot. The seeds borne by the female bracts were *Samaropsis* seeds, one of the types recognised as being Glossopteridalean. Perhaps *Vojnovskya* has developed from the *Glossopteridales*.

6. *Rigbya* Lacey et al. 1975

Lacey et al. 1975 create a new genus for fructifications which consist of a slender stalk which is expanded into a flattened head composed of several seed-bearing scales. They believe that these fructifications are referable to the *Glossopteridales*.

There are several examples of *Rigbya arberioides* Lacey et al. in the Collection.

F 29086, Figure 69, shows a specimen in which a long pedicel has its head expanded into six regular lobes. F 57653, Figure 70, shows an irregularly lobed head with two seeds in situ. Figure 71 of F 37390 is an immature example, and F 57666 (Figure 72) shows a bifurcating, lobed head.

There is no evidence at all, apart from that of association, that these fructifications are glossopteridalean.

PART VII: GENERAL DISCUSSION

The information on glossopteridalean fructifications supplied by specimens in the Australian Museum Collection is interesting and important in several respects. In the case of *Squamella* gen. nov. it explains the squamae which have been a controversial feature of the *Glossopteris* flora since earliest authors noted their regular association with the leaves. It is extremely fortunate that specimens were present which show that squamae were part of scale-fronds, that scale-fronds were aggregated into cones, and how the cones were borne on the plant. To have leaves, cones and branchlets with internal structure preserved all clearly of the same species is most unusual, and to have details of the scale-fronds of the cones so explicity demonstrated, including attachment of the sporangia, is added good fortune. Considering that the Collection is a small one and much of the material has been undetected since it was stored away at the turn of the century, it has been a most rewarding study.

The information obtained on *Partha, Eretmonia* and other genera involving small modified leaves or scales in reproduction is useful as added knowledge, and mostly new for Australia.

In the case of the multiovulate fructifications, in *Dictyopteridium* and similar genera the evidence confirms interpretations of structure made by other authors. In the case of *Ottokaria* new information may have been supplied. A controversial fructification is included in *Vannus* to stimulate discussion, and *Rigbya* is included because other authors consider its affinities are with *Glossopteris*.

LIST OF SPECIMEN NUMBERS AND LOCALITY INFORMATION FOR FIGURED SPECIMENS

Figure	Specimen	Locality	Age or Horizon
3.	57342	Flagstaff Hill, Newcastle	Late Permian
4.	57341	Flagstaff Hill, Newcastle	Late Permian
5.	57655	Bowenfels, near Lithgow, N.S.W.	Illawarra Coal Measures
6.	57316	Bowenfels, near Lithgow, N.S.W.	Illawarra Coal Measures
7.	57645	Bowenfels, near Lithgow, N.S.W.	Illawarra Coal Measures
8.	57625	Elecom Wyong DDH 6 Bore, Tuggerah Lake, N.S.W.	Late Permian
9.	57626	Elecom Wyong DDH 6 Bore, Tuggerah Lake, N.S.W.	Late Permian
10. BMR	CPC 4369	Bowen Basin, Queensland	Late Permian
11. BMR	CPC 4366	Bowen Basin, Queensland	Late Permian
12. BMR	CPC 4375	Bowen Basin, Queensland	Late Permian
13. BMR	CPC 4363	Bowen Basin, Queensland	Late Permian
14.	57659	Bowenfels, near Lithgow, N.S.W.	Illawarra Coal Measures
15.	57315	Bowenfels, near Lithgow, N.S.W.	Illawarra Coal Measures
16.	43706	Belmont, N.S.W.	Insect Beds, Late Permian
17.	43706	Belmont, N.S.W.	Insect Beds, Late Permian

18.	57667	Belmont, N.S.W.	Insect Beds, Late Permian
19.	46445	Belmont, N.S.W.	Insect Beds, Late Permian
20. MMF	18918	Glouchester, N.S.W.	Permian
20A.	18918	Glouchester, N.S.W.	Permian
21. MMF	17100	Glouchester, N.S.W.	Permian
22.	25729	Merewether Beach, Newcastle, N.S.W.	Permian
23.	44461	Burragorang Valley, N.S.W.	Illawarra Coal Measures
24.	43659	Belmont, N.S.W.	Insect Beds, Late Permian
25.	14948	Tryphinia, Queensland	Late Permian
26.	26227	Newcastle, N.S.W.	Late Permian
27.	40459	Belmont, N.S.W.	Insect Beds, Late Permian
28.	28040	Belmont, N.S.W.	Insect Beds, Late Permian
29.	25668	Crandaces Hill, Newcastle, N.S.W.	Late Permian
30.	8836	Little Red Head, Newcastle, N.S.W.	Late Permian
31.	26063	Shepherd's Hill, Newcastle, N.S.W.	Late Permian
33.	48156	Mudgee, N.S.W.	Illawarra Coal Measures
34.	48156	Mudgee, N.S.W.	Illawarra Coal Measures
36.	46525	Belmont, N.S.W.	Insect Beds, Late Permian
37.	46525	Belmont, N.S.W.	Insect Beds, Late Permian
38.	39925	Belmont, N.S.W.	Insect Beds, Late Permian
39.	41095	Belmont, N.S.W.	Insect Beds, Late Permian
40.	57391	Newcastle, N.S.W.	Late Permian
41.	29741	Merewether Beach, Newcastle, N.S.W.	Late Permian
42.	57663	Belmont, N.S.W.	Insect Beds, Late Permian
43.	41009	Belmont, N.S.W.	Insect Beds, Late Permian
45.	39934	Belmont, N.S.W.	Insect Beds, Late Permian
46.	57657	Warner's Bay, N.S.W.	Insect Beds, Late Permian
47.	41553	Belmont, N.S.W.	Insect Beds, Late Permian
48.	57624	Elecom Wyong DDH 4 Bore, Tuggerah Lakes, N.S.W.	Late Permian
49.	57662	Belmont, N.S.W.	Insect Beds, Late Permian
50.	57658	Warner's Bay, N.S.W.	Insect Beds, Late Permian
51.	57661	Belmont, N.S.W.	Insect Beds, Late Permian
52.	57622	Elecom Wyong DDH 6 Bore, Tuggerah Lakes, N.S.W.	Late Permian
53.	57623	Elecom Wyong DDH 6 Bore, Tuggerah Lakes, N.S.W.	Late Permian
55.	25655	No locality information, N.S.W.	
56.	44074	Talbragar, N.S.W.	Permian
57.	26130	Newcastle, N.S.W.	Late Permian
58.	4219	Joadja Creek, near Mittagong, N.S.W.	Permian
59.	25642	Belmont, N.S.W.	Insect Beds, Late Permian
60.	57348	Warner's Bay, N.S.W.	Insect Beds, Late Permian
61.	28183	Jamberoo, N.S.W.	Permian
62.	57485	Mudgee, N.S.W.	Illawarra Coal Measures
63.	19713	Warner's Bay, N.S.W.	Insect Beds, Late Permian
64.	19714	Warner's Bay, N.S.W.	Insect Beds, Late Permian

65.	48163	Werris Creek, N.S.W.	Permian
66.	48173	Hamilton River, Queensland	Permian
67.	57348	Belmont, N.S.W.	Insect Beds, Late Permian
68.	57347	Belmont, N.S.W.	Insect Beds, Late Permian
69.	29086	Newcastle, N.S.W.	Late Permian
70.	57666	Warner's Bay, N.S.W.	Insect Beds, Late Permian
71.	57390	Newcastle, N.S.W.	Late Permian
72.	57653	Belmont, N.S.W.	Insect Beds, Late Permian

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17 NOV 1978
OF VICTORIA

AUSTRALIAN ARCHITECTONICIDAE

T.A. GARRARD

POLYCLAD TURBELLARIANS

S. PRUDHOE

A REVISION OF THE EATONIELLIDAE

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ARTEFACTS FROM THE NORTH COAST OF NSW

I. McBRYDE

VOLUME 31 NUMBERS 13-16 SEPTEMBER, 1977 $4.00

A REVISION OF AUSTRALIAN ARCHITECTONICIDAE (GASTROPODA: MOLLUSCA)

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NATIONAL MUSEUM
17 NOV 1978
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SUMMARY

The family Architectonicidae consists of three subfamilies, Architectonicinae, Heliacinae and Pseudomalaxinae.

In the subfamily Architectonicinae five Recent species are included in the subgenus *Architectonica (Architectonica);* two Recent, three fossil (one new but unnamed) in the subgenus *A. (Discotectonica);* two Recent species in the subgenus *A. (Solatisonax);* one Recent species in the subgenus *Philippia (Philippia);* two Recent and one new fossil species *(Philippia (Psilaxis) mitchellana* Garrard) in the subgenus *Philippia (Psilaxis);* one Recent species is included as Architectonicinae sp.

In the subfamily Heliacinae, six Recent species, one of which *(Heliacus (Heliacus) hedleyi* Garrard) is new, and one new Recent subspecies *(Heliacus (Heliacus) cerdaleus ponderi* Garrard) are included in the subgenus *Heliacus (Heliacus);* 10 Recent species, one of which *(Heliacus (Torinista) corallinus* Garrard) is new, and one new fossil species *(Heliacus (Torinista) darraghi* Garrard) are included in the subgenus *H. (Torinista);* one Recent and two fossil species, one of which *(Heliacus (Awarua) otwayanus* Garrard) is described as new, and the other un-named, are included in the subgenus *H. (Awarua);* seven Recent species, one of which *(Heliacus (Claraxis) colmani* Garrard) is new, two unnamed and three fossil species, one of which *(Heliacus (Claraxis) morningtonensis* Garrard) is new and one unnamed, are included in the subgenus *H. (Claraxis).*

In the subfamily Pseudomalaxinae, two Recent species, including one new species *(Pseudomalaxis (Pseudomalaxis) thetidis* Garrard) and two fossil species are included in the subgenus *P. (Pseudomalaxis);* one Recent species is included in the subgenus *P. (Spirolaxis).*

INTRODUCTION

This revision has been compiled for the purpose of placing on record all Recent and Tertiary fossil species now known to occur in Australia. It must be noted that it is based only on shell morphology, together with opercula where possible. No attempt has been made to include anatomical or biological data as this could not have been obtained from the large majority of the species dealt with herein.

The Architectonicidae, commonly known to collectors as "sundial" shells, is the only family of Gastropoda possessing hyperstrophic protoconchs and broad conical teleoconchs, varying from moderately tall to flatly depressed; all species possess an umbilicus which varies from deep and narrow to very wide and perspective.

Records of The Australian Museum, 1977, **Vol. 31 No. 13,** 506-584, Figures 1-12.

Kosuge (1966) introduced Heterogastropoda as a suborder of the Mesogastropoda, but it has since been suggested by Climo (1975) that the suborder Heterogastropoda should be raised to ordinal rank, that it covers an ill defined but cohesive group, and may be considered as a primitive order of shelled opisthobranchs. As the ordinal name implies, the Heterogastropoda at present is used to contain certain diverse families which up to the present have presented difficulties in classification. A great deal more work obviously remains to be done in the study of soft parts and endeavouring to trace ancestry through fossil records, and until such time as this work is completed the family Architectonicidae appears to be satisfactorily placed in the above order.

The food of most, if not all species of architectonicids appears to consist, from all the evidence available at date, of various forms of coelenterates. The larger species in the genus *Architectonica* in Australia possibly live chiefly on sand dwelling sea anemones, being mainly trawled from moderately deep water on a sandy-mud bottom. Species in the genus *Philippia* are shown by Robertson, Scheltema and Adams (1970) to live in coarse sand adjoining coral reefs and to feed on the coral polyps at night. Most species in the Heliacinae are found, in tropical and sub-tropical waters in Australia, on or near shallow water reefs, probably also feeding on the coral polyps; some are dredged in coarse gravel and rubble, and some in hard-packed sand in fairly shallow water, and gorgonians and sponges as a source of food are a possibility. Much research remains to be done to confirm these suppositions or otherwise.

Larval distribution. The long pelagic existence of the larvae of many species in the family would probably account for the disjunct range shown by a number of species in Australia, depending to a great extent on ocean currents for their dispersal. Robertson (1964:1), writing on the genus *Philippia,* shows probable carriage by ocean currents of larvae of *Philippia krebsii* Morch a total distance of 3,450 km from the West Indies to the Sargasso Sea. Robertson, Scheltema and Adams (1970:55) state "duration of the pelagic larval stage is between several weeks and six months or longer." These remarks most likely apply also to a number of other species in the family as a whole.

A period of postlarval arrested growth occurs in the first teleoconch whorl of many species, and occurs shortly after settling to a benthic existence. At least one break occurs in most species, often two, and following this stage, during the search for a host, Robertson, Scheltema and Adams state (1970:55) that the postlarvae can remain alive without food for a period of several months in the case of *Philippia* species. These breaks in the first teleoconch whorl are very apparent in most species of Heliacinae, but barely visible in most species of Architectonicinae, appearing merely as faint growth lines.

Protoconchs. The protoconch is the most important character used to determine the placement or otherwise of any species in the family Architectonicidae, especially in the case of a number of minute species with depressed teleoconchs encountered in other families. The hyperstrophic protoconchs of the architectonicids have the whorls rising above the nucleus, which may be viewed through the umbilicus. The term "anastrophe" was proposed by Dautzenberg and Fischer in 1896 to distinguish the architectonicid protoconch from the hyperstrophic protoconchs of the pyramidellids and mathildids, which are set at far wider angles from the teleoconch axes.

These anastrophic protoconchs show differences in coiling, but generally speaking are remarkably uniform throughout the family, the whorls being mostly "regularly" coiled, some inflated, smooth and shining, the peritreme entire and forming an expanded and reflected varix. The axis of coiling of the protoconchs is set at a very slight angle from the teleoconch, never exceeding about 10°. The diameter of the protoconch obviously cannot be utilised alone for the separation of species, but taken in conjunction with other features can be of assistance in a number of cases.

MATERIAL AND METHODS

Only specimens from the various State Museum collections have been utilised. Apart from uniform descriptions and technical data, comparisons have been made with other closely related species to enable recognition without difficulty. Some minor taxonomic references have been omitted in various cases, those included being all references to the original authors, those containing references to figures, and also references to Australian authors. The taxonomic characters utilised in descriptions of the various species are all considered to be of equal importance, and every portion of each shell, protoconch, teleoconch, sculpture, aperture, etc., is described in detail in each case.

Method of protoconch measurement. The Architectonicidae is one of the few families where measurement of the exposed dorsal portion of the protoconch is rendered comparatively simple owing to its depressed nature. A calibrated optic lens through which to view a micro-millimetre scale at a magnification of 30X was utilised to draw a graph whereby measurements could be made to 1/100th mm of the dry protoconchs of all species dealt with in this revision, measuring from the outer edge of the varix to the far side of first whorl.

SUMMARY OF SUBFAMILIES, GENERA and SUBGENERA DEALT WITH IN THIS REVISION

Subfamily ARCHITECTONICINAE

Architectonica *(Architectonica)* Roding, 1798
(Discotectonica) Marwick, 1931
(Solatisonax) Iredale, 1931
Philippia *(Philippia)* Gray, 1847
(Psilaxis) Woodring, 1928

Subfamily HELIACINAE

Heliacus *(Heliacus)* Orbigny, 1842
(Torinista) Iredale, 1936
(Awarua) Mestayer, 1930
(Claraxis) Iredale, 1936

(Refer to explanatory remarks under heading HELIACINAE in Systematic section).

Subfamily PSEUDOMALAXINAE

Pseudomalaxis *(Pseudomalaxis)* Fischer, 1885
(Spirolaxis) Monterosato, 1913

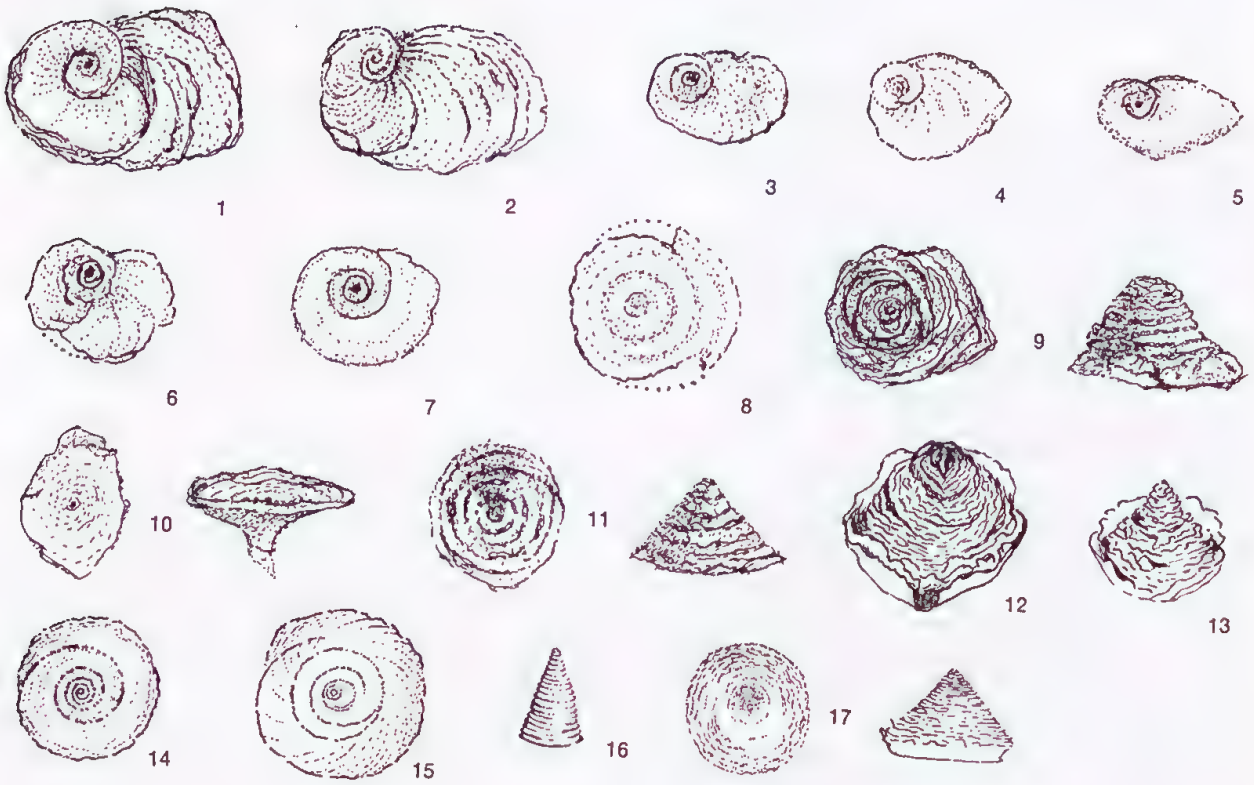
ORDER OF PRINTING

The type for each genus is printed first if it occurs in Australian waters, otherwise all are in alphabetical order. An index to genera and species is provided at end of the revision.

ABBREVIATIONS USED

A.I.M. Auckland Institute and Museum, Auckland, N.Z.
A.M. Australian Museum, Sydney, N.S.W.

B.M.N.H.	British Museum (Natural History), London, SW7, England.
N.M.N.Z.	National Museum of New Zealand, Wellington, N.Z.
N.M.V.	National Museum of Victoria, Melbourne, Victoria.
Q.M.	Queensland Museum, Brisbane, Queensland.
Q.V.M.	Queen Victoria Museum, Launceston, Tasmania.
S.A.M.	South Australian Museum, Adelaide, South Australia.
T.M.	Tasmanian Museum, Hobart, Tasmania.
U.S.N.M.	National Museum of Natural History, Smithsonian Institution, Washington, D.C., U.S.A.
W.A.M.	Western Australian Museum, Perth, Western Australia.



Opercula.1, *A. (A). perspectiva*. X 2.2, *A. (A). maxima* X 2.3, *A. (A). perdix* X 2.7. 4,*A. (A). reevei* X 3.3.5,*A. (A). modesta* X 5.6,*A. (D). acutissima* X 2.5. 7,*A.(D). kuroharai* X 4.8,*A. (S). injussa* X 4.9,*H. (H). stramineus* X 2 (dorsal and side views). 10, *P. (P). novilis meridionalis* X 7 (dorsal and side views). 11, *H.(H).variegatus* X 4 (dorsal and side views). 12, *H.(H). variegatus* X 5. 13, *H. (H). variegatus* X 4. 14, *P. (P). lutea* X 4.5. 15, *P. (Ps). radiata* X 4.5. 16, *H. (C). asperus* X 2.5. 17, *H. (T). dorsuosue* X 6 (dorsal and side view). Fig. 9, 11, 12, 13 and 17 are typical also of *H. (H). hedleyi, H. (H). enoshimensis, H. (H). madurensis, H. (T). fenestratus* and *H. (C). foveolatus*. Figs. 1-11, T. Ireland del. 12-17, J. B. Aitken del.

SYSTEMATIC SECTION

Subfamily ARCHITECTONICINAE

DIAGNOSIS: Mainly heavy and solid species, 30-70 mm max. diam., a few as small as 7.5 mm. Single peripheral keel. Sculpture of strong cords and grooves, granose, tessellated or almost smooth. Umbilicus wide and perspective to narrow. Operculum chitinous, thin and flat.

Genus ARCHITECTONICA Roding, 1798

Subgenus ARCHITECTONICA Roding, 1798. Type species by subsequent designation *Trochus perspectivus* Linnaeus, 1758 (Gray, 1847:151 — mis-spelt *Architectoma*).

REFERENCES: Brookes, 1815:123; H. and A. Adams, 1858:241; Chenu, 1859:232 (*Solarium*); Tryon, 1887:5 (*Solarium*); Suter, 1913:315; Wenz, 1938-44:670; Bayer, 1940:223 (*Solarium*).

SYNONYMS: *Solarium* Lamarck, 1799. Type species by original designation *Trochus perspectivus* Linnaeus, 1758.

DIAGNOSIS: Large to very large, medium to low conical; medium to wide perspective umbilicus; strong peripheral keel separated by a deep groove from both a dorsal and basal cingulum; usually both axially and spirally grooved and beaded, especially in early whorls; flat horny operculum. No species in this subgenus recorded from any Australian locality possesses an anal keel on protoconch.

Architectonica (Architectonica) perspectiva (Linnaeus, 1758) Figs. 1 (1-6), 2 (1-3).

Trochus perspectivus Linnaeus, 1758:757, no. 503: 1767:1227, no. 581; Gmelin, 1791:3566, no. 3.

Architectonica perspectiva. — Roding, 1798:78, no. 1022; Hedley, 1918:101; Oostingh, 1925:29-32; Tomlin, 1928:332; Wilson and Gillett, 1971:34, pl. 13, fig. 11.

Solarium perspectivum — Lamarck, 1799: . — Montfort, 1810:163. — Lamarck, 1816: pl. 46, fig. 1. — Wood, 1825:137, pl. 29, fig. 62c. — Sowerby (1820-25) 1831, no. 38, pl. 202. — Reeve, 1864, sp. 11, pl. 2, fig. 11b (not 11a). — Fischer, 1887:715, pl. 9, fig. 15. — King and Ping, 1931:269, fig. 4.

Solarium incisum Philippi, 1849:169, no. 45; 1853:27, no. 30, pl. 4, fig. 6.

Solarium formosum Hinds, 1844:22. — Bayer, 1940:243.

Solarium (Architectonica) perspectivum. — Hanley (Sowerby), 1863:228, pl. 4 (253), figs 36-38.

Solarium australe Philippi, 1849:168 (non Morch, 1875). — Bayer, 1940:242.

Solarium perspectivum var. *heurni* Bayer, 1940:243, fig. 4.

Architectonica perspectiva fressa Iredale, 1936:325, pl. 23, fig. 20.

DESCRIPTION: *Protoconch* regularly coiled, varying .83-1.00 mm diam. *Teleoconch* depressed conic, up to 9½ convex whorls in width of 60 mm, base flatly convex. *Sutures* deeply incised, joined above peripheral keel. *Sculpture* consists of 2 nodular cords, at either margin of whorls, upper cord larger and flattened, with deep narrow sulcus below

it, lower cord higher but narrower; axial sculpture of strong deep oblique grooves across all whorls, resulting in formation of many elongate oblique segments, in addition to fine growth lines; lower nodular cord on body-whorl is divided from peripheral keel by a strong narrow cingulum; this cingulum and the peripheral keel are both covered by suture in earlier whorls; sculpture of base consists of a wide strong rounded cord divided from peripheral keel by one fine narrow cord, and whole base is covered by strong flattened ridges axially with narrow interstices; channels in base covered with light brown periostracum in live specimens. *Umbilicus* widely perspective, 36-40% of shell diameter at maturity; unbilical cord with crowded axially elongate crenulations, centrally ridged and bluntly pointed; outer periumbilical cord with smaller elongate nodules, with a deep sulcus on either side; umbilical canal with convex base, strongly obliquely wrinkled, covered with light brown periostracum. *Aperture* sub-rhomboid, wider towards outer-lip; inner-lip straight with two narrow channels below, extending into aperture for short distance. *Colour* greyish-fawn, chocolate-brown and white (or light brown) spots alternately on lower nodular cord adjoining keel; reddish-brown and white spots alternately on peripheral keel; nodular cord below sutures brown on upper half and white below; a further band of square black-brown spots, or alternatively a continuous black-brown band occurs below the bi-coloured band; heavy cingulum on base adjoining peripheral keel is brown and white spotted; square-cut ends of flattened ridges towards umbilicus are chocolate brown; smaller periumbilical cord whitish with red-brown interstices; main umbilical cord usually medium brown. *Operculum* fawn, widely elliptic, fibrous horny material with thin lamellate growth layers ascending counter-clockwise; nucleus in small spiral depression in top left corner; usual mamillate projection behind nucleus.

TYPE LOCALITY: "Asiae littora" (Linnaeus). Amboyna; Australia (Reeve).

DIMENSIONS: Holotype, 2¼ pollices (Gmelin) = 57.1 mm. Largest specimen examined, max. diam. 61.2 mm, min. diam. 55.1 mm, alt. 35.3 mm, 9½ whorls.

LOCATION OF TYPE: Linnaean Society, London, reg'd number not ascertained.

DISTRIBUTION: From W. of North-West Cape, W. Australia (21° 50′ S., 113° 46′ E.), northwards round Northern Territory, Gulf of Carpentaria, southwards along Queensland coast to Sydney Harbour, New South Wales. Greatest depth recorded, 54 metres off Tweed Heads, New South Wales. Widespread throughout Indo-Pacific and northwards to Japan, tropical to temperate.

MATERIAL: W. of North-West Cape as above, 2 specimens coll. C.S.I.R.O., Stn. 173, 6/10/1963, W.A.M. No. 58-73. Furthest south on east coast as above, Sydney Harbour, holotype of *A. perspectiva fressa* Iredale, A.M. No. C. 60679. Greatest depth as above, 54 metres Tweed Heads, ex T. A. Garrard coll, A.M. No. C. 87101, which is also largest specimen examined as above. Total specimens examined from all Australian Museums 477 (160 lots). Probably 30% of all specimens brought up by trawl nets in southern Queensland and northern New South Wales are taken alive, but most have the mollusc and operculum removed before sale and an accurate percentage is not possible.

DISCUSSION: The colour pattern in this species varies considerably throughout its range, also the position of the suture to a small extent, being placed occasionally at base of a deep narrow canal; examination of many specimens from Queensland and New South Wales shows a number conforming in colour to the descriptions of the five varieties included in the synonymy. An interesting colour variation is illustrated at fig. 1(1-3) from 37-49 metres off Yamba, New South Wales, the usual second dark band below the suture being replaced by oblique axial stripes. A number have been taken from this area, some also having basal striping. In 2 specimens from Groote Eylandt, Northern

Territory, pure white crenulations on last 2 whorls of umbilical cord replace light brown in primary whorls (A.M. No. C. 69038).

The elongate oblique segments formed by the intersections of axial grooves with the one spiral sulcus, contrast with the granulated appearance of the early whorls in *Architectonica maxima* (Philippi). The whorls are also narrower in *A. perspectiva*, resulting in a shell at maturity with approximately one more whorl than a specimen of *A. maxima* of equal diameter.

Architectonica (Architectonica) maxima (Philippi, 1848) Fig. 2 (4-9).

Solarium maximum Philippi, 1848:170, no. 47; 1853:6, no. 2, pl. 1, figs 2, 3. — Reeve, 1864, pl. 1, fig. 4. — Marshall (Tryon), 1887:9, pl. 3, fig 31, 32. — Hedley, 1903:349, fig. 73. — Bayer, 1940:227.

Solarium (Architectonica) maximum. — Sowerby, 1863:229, pl. 1, figs 5, 6.

Solarium taylori Hanley (Sowerby), 1863:230, pl. 3, figs 31, 32; Marshall (Tryon), 1887:10, pl. 3, figs 33, 34.

Architectonica maxima. — Hedley, 1917:101; Wilson and Gillett, 1971:34, pl. 13, fig. 12.

Architectonica grandiosa Iredale, 1931:228, pl. 25, figs 19, 20.

Solarium grandiosum. — Bayer, 1940:226.

DESCRIPTION: *Protoconch* regularly coiled, varying from .83-1.00 mm diam. *Teleoconch* depressed conic, 8½ flatly convex whorls in diam 70 mm, base flatly convex. *Sutures* deeply impressed, joined above peripheral keel *Sculpture* of 4 gemmate cords on each whorl, becoming flat-topped and smoother on penultimate and body-whorl, separated by deep square-cut spiral grooves, the whole crossed by deeply incised axial grooves on all whorls, resulting in a general gemmate appearance; sculpture on base consists of a rounded spiral cord near periphery, separated from larger peripheral keel by a square-cut sulcus; this is followed by a wide space, then 2 further square-cut sulci with narrow crenulated cord between, the whole crossed by fine growth lines; basal sulci usually show signs of light brown periostracum on good specimens. *Umbilicus* widely perspective, averaging 30% of shell diameter at maturity, encircled by heavy white cord with sharp-edged and pointed crenulations; umbilical canal with convex base, strongly wrinkled, covered with folded light brown periostracum. *Aperture* sub-quadrate, external edge and base crenulated by cords, inner-lip straight or slightly arcuate, with deep narrow groove below. *Colour* light greyish-fawn, flattened cingulum below suture with brown and white spots alternately; peripheral keel and cingulum above, also cingulum on base adjoining, are similarly coloured; second smaller periumbilical cord finely spotted brown, and 2 or 3 rows of square brown spots or dashes extend further towards edge of base. *Operculum* light brown, horny, with close-packed fine curved overlapping scales, radiating from nucleus in a coiled circular depression in top left corner counter clockwise, at rear of which is a well raised mamillate nodule.

TYPE LOCALITY: None given. Reeve states "Java; Ceylon."

DIMENSIONS: Holotype, max. diam. 64.3 mm, alt 29.8 mm. Approx. max. size 70 mm, 8½ whorls.

LOCATION OF TYPE: Unknown, unable to trace.

DISTRIBUTION: Shark Bay, Western Australia (25° 30′ S., 113° 30′ E.), northwards to 32 km N.W. of Anchor Island, off Onslow, Western Australia (21° 31′ S., 114° 46′ E.),

eastwards along whole northern coastline, and southwards along Queensland and New South Wales coasts to Port Jackson. Greatest depth recorded, 114-124 metres N.E. of Cape Moreton, Queensland (27° 02' S., 153° 28' E.) Widespread throughout eastern Indian Ocean, western Pacific Ocean and northwards to Philippine Islands and Japan.

MATERIAL: Shark Bay as above, 1 specimen coll F. Back 7/1960, W.A.M. No. 149-73. Off Anchor Island as above, 6 specimens, 118 metres, 17/6/60, W.A.M. No. 71-73. Port Jackson as above, 1 specimen *"Triton"* dredge, eastern channel, ex J. Kerslake coll, A.M. No. C. 91666. Greatest depth as above, 1 specimen ex T.A. Garrard coll, A.M. No. C. 91667. Total specimens examined from all Australian Museums 88 (56 lots). The same remarks apply to this species as they do to *Architectonica perspectiva* regarding live specimens, probably 30% or more being taken alive in southern Queensland and northern New South Wales, but exact percentage is a matter of conjecture.

DISCUSSION: This species is very variable in colour pattern, the various spots and dashes of brown being distributed indiscriminately in many specimens, and the two species *Solarium taylori* Hanley and *Architectonica grandiosa* Iredale both fall within the range of variation. A brown coloration is also found on the crenulations of the umbilical cord in some instances. One feature which invariably separates this species from *A. (Architectonica) perspectiva* is the presence of at least two, usually three, sharply-cut spiral sulci between the sutures and periphery, compared with one only in all specimens of *A. (A). perspectiva* examined.

Architectonica (Architectonica) modesta (Philippi, 1848) Fig. 1 (7-9)

Solarium modestum Philippi, 1848:171; 1853:15, pl. 3, fig. 1; Reeve, 1864: pl. 2, fig. 12; Marshall (Tryon), 1887:9, pl. 2, figs 22, 23; Bayer, 1940:228.
Solarium (Architectonica) modestum. — Hanley (Sowerby), 1863:229, pl. 1, figs 11, 12; pl. 3, figs 27, 28.

DESCRIPTION: *Protoconch* regularly coiled, varying 1.00-1.17 mm diam. *Teleoconch* depressed conic, 6½ whorls in width of 36 mm, becoming increasingly convex, base flatly convex. *Sutures* well impressed, joined above peripheral keel. *Sculpture* — two strongly beaded spiral cords below sutures, becoming smooth on body-whorl at maturity, a sharply-cut sulcus below each, one flatly-beaded cord towards periphery, flatly-ribbed space between; peripheral keel on body-whorl lightly axially grooved, covered by sutures in earlier whorls; fine rounded ridge on base separates peripheral keel from a further high rounded cingulum, central area of base lightly axially grooved. *Umbilicus* perspective, 30% of shell diameter at maturity, umbilical cord with sharply pointed crenulations; a further flat-topped periumbilical cord surrounds the first, grooved on either side; umbilical canal flat-based, crossed by strong irregular growth lines. *Aperture* sub-quadrate, three fine grooves behind peripheral keel and adjoining cingula, two further fine grooves at base of inner-wall, which is vertical. *Colour* – sub-sutural cingulum white, only occasionally spotted with brown, adjoining cingulum continuous dark brown, alternatively light brown with dark brown spots ; central space light grey-brown, adjoining cord spotted, peripheral keel white or spotted brown; base light greyish-white, umbilical cord white, very seldom spotted brown; a few scattered brown spots on base of some specimens. *Operculum* thin, concave and chitinous, horn-coloured, widely elliptic, concave nucleus near top inner margin, spiral to commence then expanding rapidly in size counter-clockwise, with strong curved growth lines curved clockwise; reverse side attached to mollusc in shell and not observed.

TYPE LOCALITY: Unknown (author). "China; Society Islands" (Reeve).

DIMENSIONS: Holotype, diam. 25.37 mm, alt. 11.63 mm, diam. of umbilicus 7.4 mm. Average full grown specimen, max. diam. 36 mm, minor diam. 30 mm, alt. 17 mm, 6½ whorls.

LOCATION OF TYPE: Unknown, unable to trace.

DISTRIBUTION: W. of Flat Island, near Onslow, Western Australia across north coast and southwards down Queensland coast, noted from Port Douglas, north Queensland (16° 29′ S., 145° 28′ E.), off Noosa Heads, 106 metres, to N.E. of Cape Moreton, Queensland (27° 02′ S., 153° 28′; E.), 125 metres. Extends throughout Indonesia, Philippine Islands, Papua New Guinea, Solomon Islands, New Hebrides to Tahiti, also China coast and Japan. Shallow water to 125 metres.

MATERIAL: W. of Flat Island as above, two specimens 19/6/60, W.A.M. No. 77-73. Port Douglas as above, one specimen, A.M. No. C. 22076. Off Noosa Heads as above, one specimen pres. Ron Evans, A.M. No. C. 98862. Off Cape Moreton as above, two specimens pres. L. Moore, A.M. No. C. 98750. Total specimens examined from all Australian Museums 24 (11 lots).

DISCUSSION: This species bears a strong general resemblance to *A. (Architectonica) perspectiva* (Linnaeus), but can be distinguished by the following four points:

1. The protoconch is larger and more inflated, 1.00-1.17 mm diameter compared with. 83-1.00 mm in *A. (A). perspectiva.*
2. The cord of white beads below the suture, becoming smooth with age, frequently has a few scattered small brown spots on the body-whorl, but is never completely brown on the upper-half as in *A. (A). perspectiva.*
3. The dark brown band immediately below the above white cord has a clear-cut sulcus below it, in addition to the sulcus above it found in both species.
4. The crenulated umbilical cord is usually pure white, only rarely brown spotted.

Architectonica (Architectonica) perdix (Hinds, 1844) Fig. 1 (13-15)

Solarium perdix Hinds, 1844a:22; 1844b:50, pl. 14, figs 3, 4; Philippi, 1853:8, pl. 1, figs 8, 9; Reeve, 1864: pl. 1, fig. 1; Marshall (Tryon), 1887:9, pl. 2, figs 24, 25; Bayer, 1940:233.
Solarium (Architectonica) perdix. — Hanley (Sowerby), 1863:233, pl. 2, figs 17, 18.

Architectonica perdix. — Hedley, 1916:46; Rippingale and McMichael, 1961:63, pl. 6, fig. 25; Wilson and Gillett, 1971:34, pl. 13, fig. 9.

DESCRIPTION: *Protoconch* regularly coiled, vaying .65-.83 mm diameter. *Teleoconch* conic, seven flatly convex whorls in width of 37 mm, body-whorl contracting towards base, base of shell slight convex in centre. *Sutures* finely and deeply incised, joined above peripheral keel. *Sculpture* — two nodular spiral cords commence on first whorl, the uppermost adjoining suture above and finer than that below, which is close to lower suture; both cords expand in size and become flattened with age; wide area between cords strongly incised by numerous growth lines; body-whorl shows peripheral keel divided into two rows of flat square nodules, suture covering lower row in preceding whorls; base of shell slightly convex in centre; a strong spiral cord runs closely inside peripheral keel, whole base crossed by numerous strong growth lines; remains of fawn periostracum in channels when in good condition. *Umbilicus* perspective, average 23% of shell width at maturity, umbilical cord with strong crenulations, axially ridged and serrated; second smaller periumbilical cord of more flattened nodules and having a strongly incised line on either side; umbilical canal with convex base, strongly wrinkled,

covered with fawn periostracum. *Aperture* sub-rhomboid, inner-lip vertical with narrow channel beneath for short distance; outer-lip thin and simple. *Colour* greyish-fawn, nodular cords both above and below sutures spotted with brown; peripheral keel and adjoining cord on base similarly spotted; faint brown markings occasionally on either or both periumbilical cords. *Operculum* fawn, broadly ovate, of fibrous horny material, slightly concave, deeply depressed nucleus towards top left corner, numerous thin lamellate growth layers coiled counter-clockwise; a small protuberance consisting of several minute nodules at rear of nucleus.

TYPE LOCALITY: "Ceylon; N.W. coast of Australia." (Hinds).

DIMENSIONS: Holotype, max. diameter 34.5 mm, min. diameter 28.7 mm, alt. 18 mm. (Hinds drawing). Approximate max. size 37 mm with 7 whorls.

LOCATION OF TYPE: Should be with B.M.N.H. but cannot be traced.

DISTRIBUTION: Western Australia, Cambridge Gulf — Lower Ord River (14° 55′ S., 128° 15′ E.), eastwards through Darwin, Millingimbi and Crocodile Island, Northern Territory; off Normanton, Gulf of Carpentaria, and southwards along Queensland coast to Bargara, Burnett River mouth, Queensland (24° 49′ S., 152° 28′ E.), widely distributed north and north-east of Australia, through Indonesia, P.N.G., Solomon Islands, Penang and Malaysia. Sub-tidal.

MATERIAL: Cambridge Gulf as above, 1 specimen coll B. G. Thom June 1971, W.A.M. No. 151-73; Darwin as above, three specimens, A.M. No. C. 12226; Millingimbi as above, two specimens ex J. Kerslake coll, A.M. No. C. 91670; off Normanton as above, two specimens ex T.A. Garrard coll, A.M. No. C. 91671. Total specimens examined from all Australian Museums 322 (54 lots).

DISCUSSION: The closest congener to this species is *A. (Architectonica) reevei* Hanley. The main differences are:

1. The small protoconch in the within species, .65-.83 mm compared with 1.00-1.18 mm diam. in *Architectonica reevei*.
2. The sharply pointed crenulations on umbilical cord compared with the rough crowded crenulations in *A. reevei*.
3. No spiral grooves or ridges on the broad central area of each whorl, compared with several grooves and ridges in *A. reevei*.
4. Position of suture — see "Discussion" under *A. (A). reevei*.

Architectonica (Architectonica) reevei (Hanley, 1862) Fig. 3 (1-9)

Solarium reevei Hanley, 1862:204. — Reeve, 1864: pl. 3, fig. 20; Marshall (Tryon), 1887:12, pl. 4, figs 45, 46; Iredale, 1931:228; Bayer, 1940:251.

Solarium (Architectonica) reevei. — Watson, 1886:136; Hanley (Sowerby), 1863:234, pl. 250, figs 9, 10.

Architectonica reevei. – Angus, 1867:201. — Hedley, 1917:102; May, 1923:97, pl. 46, fig. 2; Wilson and Gillett, 1971:34, pl. 13, fig. 10.

Architectonica offlexa Iredale, 1931:229, pl. 25, figs 15, 16.

Architectonica relata Iredale, 1936:326, pl. 23, fig. 19.

DESCRIPTION: *Protoconch* elevated and inflated, varying 1.00-1.18 mm diam. *Teleoconch* conical, 6½ flatly convex whorls in diam. of 30 mm, base flatly convex. *Sutures* strongly incised, joined at centre of peripheral keel. *Sculpture* commences with

one small nodular cord at top and two at base of each whorl; from third whorl onwards a second flatly nodular cord develops at top, after which further incised lines appear, resulting in 3-4 flat cords between the double row of nodules on each whorl, but in suppressed form in some specimens; whole sculpture crossed by oblique microscopic growth lines; base of shell with one fine cord adjoining peripheral keel, whole base crossed by numerous fine growth lines. *Umbilicus* perspective, varying widely from 23% to 30% of shell diameter at maturity; umbilical cord with strong axially ridged crenulations, a second smaller periumbilical cord with flat nodules; umbilical canal flat-based, strongly obliquely wrinkled, covered with pale straw coloured periostracum. *Aperture* sub-rhomboid, inner-lip straight and vertical, a fine narrow groove below for short distance into aperture. *Colour* light greyish-fawn, nodular cords both above and below sutures brown spotted, also peripheral keel and cingulum above; cord adjoining peripheral keel on base and two periumbilical cords similarly spotted; wide space between cords often has 2-3 rows of microscopic brown spots. *Operculum* fawn chitinous material, broadly ovate, thin and frail, concave, coiled counter-clockwise, microscopic overlapping growth ridges curved clockwise, nucleus in centre of depressed section in top left corner; small mamillate protuberance behind nucleus.

TYPE LOCALITY: None given. "Sydney" (Reeve).

DIMENSIONS: Holotype, diam. 22 mm, alt. 14 mm. Average fully grown specimen approx. 30 mm x 17 mm, 6½ whorls.

LOCATION OF TYPE: The specimen figured by Hanley in *Thes Conch* (Sowerby), 3:234, pl. 250, figs 9, 10, and also that figured in *Conch Icon* (Reeve) 15, pl. 3, fig. 20, are both held at B.M.N.H. It is uncertain whether either of these two specimens from the Cuming coll. is that from which Hanley made his original description in *Proc Zool Soc Lond*, 1862:204, since he mentioned only one shell and gave no locality.

DISTRIBUTION: On west coast, two records, S.W. of Point Cloates, Western Australia (23° 39′ S., 113° 11′ E.), and 160 km N.W. of Roebuck Bay (16° 58′ S., 120° 47′ E.), 194 metres. Range is disjunct until appearnce in South Australia, not recorded from Victoria but probably lives on Gippsland coast, and in Tasmania appears only to be recorded from Marion Bay on S.E. coast (42° 48′ S., 147° 55′ E.) Northwards the species is common in southern New South Wales, becoming scarcer further north, limit of range being southern Queensland in vicinity of Caloundra-Cape Moreton area (27° 02′ S., 153° 28′ E.) Greatest depth recorded 137 metres off Broken Bay, New South Wales (33° 33′ S., 151° 20′ E). Mainly sub-tidal. Also occurs in North Island of New Zealand.

MATERIAL: N.W. of Roebuck Bay as above, 1 specimen coll B.M.R. 29/11/67, M.V. *"Kos 2"* (K67-248), A.M. No. C. 95293. Marion Bay as above, N.M.V. (ex Q.V.M.), 2 specimens, not reg-d. Cape Moreton as above, 5 specimens 114-124 metres, ex T. A. Garrard coll. A.M. No. C. 91675. Greatest depth as above off Broken Bay, 3 specimens ex T. A. Garrard coll, A.M. No. C. 91677. Total specimens examined from all Australian Museums 187 (64 lots).

DISCUSSION: An almost infallible recognition point in this species is the position of the suture, joined directly to the centre of the peripheral keel in lieu of to the base of the groove above it. This fact was pointed out by the author.Hanley (1862:205) and also by Bayer (1940:251), who stated that he knew of no other species in the genus where this occurs. This feature is quite clear in the holotypes of *Architectonica offlexa* Iredale, 1931, and also *A. relata* Iredale, 1936, which are both conspecific. This feature is also common to the genus *Philippia*.

Two specimens off Cronulla, New South Wales, 80 metres, coll J. McIntyre 3/2/65, 5 adult whorls, A.M. No. C. 90550. (One specimen, after completion of one main whorl, transferred suture below peripheral keel, on to groove between peripheral keel and adjacent cingulum, giving an imbricating effect to shell, there being no sign of breakage to cause alteration).

Two specimens, Watson's Bay, New South Wales (Port Jackson), coll 1930, A.M. No. C. 73585. (In these two further shells suture is attached to base of peripheral keel in lieu of centre, which does not give any effect of imbrication; however, in last 5 mm of body-whorl one has transferred suture underneath into groove as with one noted above).

Specimen shown under "Distribution" from 160 km N.W. of Roebuck Bay, Western Australia, is only 7.1 mm diam. and is clear and glass-like. However, all features, including position of suture, are clearly those of *A. (A). reevei,* and in view of the other record above from Point Cloates, W. Australia, it is accepted as being this species.

Subgenus *DISCOTECTONICA* Marwick, 1931:101. Type species by orginal designation *Architectonica balcombensis* Finlay, 1927a:501 (new name for *Solarium acutum* Tenison-Woods, 1879, non Conrad 1860).
References: Wenz, 1938-44:671.
Synonyms: Acutitectonica Habe, 1961: Append. 10. Type species by original designation *Solarium acutissimum* Sowerby, 1914. *Russetia* Garrard, 1961:23. Type species by original designation *Russetia dilaniatus* Garrard (= *Discotectonica acutissima* (Sowerby, 1914).

DIAGNOSIS: Large, acutely depressed conic; large perspective umbilicus; periphery flatly compressed without distinct keel or adjoining cingula as in *Architectonica;* suture follows periphery, which is therefore not embraced by the ovate aperture. (In common with the synonymous subgenus *Acutitectonica* this subgenus does not possess an anal keel on the protoconch).

Architectonica (Discotectonica) acutissima (Sowerby, 1914) Fig. 1 (16-18), 2 (19-21)

Solarium acutissimum Sowerby, 1914:36, pl. 2, fig. 9.
Acutitectonica acutissima. – Habe, 1961:30, pl. 13, fig. 21; Habe, 1964:46, pl. 13, fig. 21.
Russetia dilaniatus Garrard, 1961; 23, pl. 1, fig. 11.

DESCRIPTION: *Protoconch* regularly coiled, .76 mm diam. *Teleoconch* flatly depressed, 6½ whorls in diam. of 38 mm at maturity, slightly concave; base concave near periphery, convex in centre. *Sutures* obscured by peripheral keel of previous whorl and slightly imbricating. *Sculpture* of 8-10 raised spiral cords, tending to bifurcate on body-whorl and penultimate; in early whorls these are bounded by a thicker gemmate cord adjoining the crenulate periphery, which becomes smoother with maturity; whole sculpture decussated by numerous fine growth lines; sculpture of base consists of numerous incised spiral lines, crowded near periphery, with narrow rounded cords between, more widely spaced towards umbilicus with flat areas between, the whole over-ridden by numerous fine growth lines. *Umbilicus* widely perspective, averaging 32% of shell width at maturity; umbilical cord with crowded sharply raised and pointed crenulations, which tend to flatten with maturity; a finely incised sulcus separates umbilical cord from a further sharply crenulated periumbilical cord, then a broad spiral sulcus, followed by a third cord of more flattened nodules; umbilical canal flat-based, strongly obliquely striated. *Aperture* flatly ovate, constricted towards periphery, inner

margin straight but inclined to right at base, a narrow groove below it. *Colour* cream, tending to light grey below sutures with oblique radial fawn streaks,a fawn band in top centre of aperture, edge of umbilicus lightly tinted with same colour. *Operculum* widely ovate with sub-marginal concave nucleus, spiral layers of thin fawn chitinous material, with light brown ring round nucleus and brown rays radiating towards periphery; expands rapidly in area, finely irregularly granulated over whole surface.

TYPE LOCALITY: Kii (Wakayama Pref.), Honshu, Japan.

LOCATION OF TYPE: B.M.N.H. Reg'd. No. 1915/1:6:100.

DIMENSIONS: Holotype, max. diam. 33.5 mm, alt. 11.8 mm. Approx. max. size 38 mm x 15 mm alt., 6½ whorls.

DISTRIBUTION: Off Cape Moreton, southern Queensland (27° 02′ S., 153° 28′ E.), to Newcastle, New South Wales (32° 58′ S., 152° 03′ E.) Extends northwards to Philippine Islands and Japan.

MATERIAL: A.M. 1 live specimen 114-124 metres N.E. of Cape Moreton, southern Queensland, coll D. Harris 1967, A.M. No. C.91657. 1 specimen 293 metres off Newcastle, New South Wales, ex *"Challenge"* 1960, A.M. No. C.63345 (Type of *Russetia dilaniatus* Garrard, 1961). Total specimens examined — A.M. 4, including 2 from Japan.

DISCUSSION: This species differs from its nearest congener *A. (Discotectonica) kuroharai* (Kuroda and Habe) by the rough and irregular appearance of the cords in the latter species, which not only vary in width, but the surface of the shell in that species also undulates in an irregular manner; also the totally different colour patterns as shown in descriptions.

The within species does not differ greatly from the Victorian Tertiary fossil species *A. (Discotectonica) balcombensis* Finlay; the spirals in the fossil are more granulated and the whorls do not imbricate to the same degree; basally the sculpture in the fossil has a more tessellated appearance, and the crenulations of the umbilical cords are over-ridden by more prominent spirals. As *A. (D). acutissima* has been found as far south as Newcastle the possibility that the fossil was ancestral is a distinct possibility.

Architectonica (Discotectonica) kuroharai Kuroda and Habe, 1961 (Fig. 1 (10-12)

Architectonica kuroharai Kuroda and Habe, 1961: Append 9, pl. 13, fig. 20

DESCRIPTION: *Protoconch* regularly coiled, varying .65-.70 mm diam. *Teleoconch* flatly depressed, 6½ flatly concave whorls in diam. of 28 mm, base convex with depression adjoining periphery. *Sutures* joined below peripheral keel, which imbricates over succeeding whorl. *Sculpture* — a cord of fine elongate nodules forms peripheral keel, commencing immediately following protoconch, nodules increasing in size but coalescing with age, and forming a rough and irregular edge to shell; a further cord of finer nodules commences sub-suturally on first whorl, bifurcating on third whorl, becoming irregular and uneven, and accompanied by 7-8 other irregular flattened cords; whole sculpture is crossed by oblique and uneven growth lines; sculpture of base consists of up to 14 uneven and irregular cords of varying widths crossed by irregular growth lines. *Umbilicus* widely perspective, averaging 39% of shell diameter at maturity; umbilical cord with heavy regular pointed crenulations; two further periumbilical cords of more flattened square nodules, axially elevated; umbilical canal with convex base, strongly and irregularly axially wrinkled. *Aperture* triangularly ovate, base slightly convex, inner-lip inclined inwards basally with fine narrow channel below. *Colour* cream and white ground, brown and white spots alternately on periphery, base white.

Operculum of thin fawn chitinous material, concave sub-central nucleus, spiral layers expanding rapidly in size, finely irregularly granulated over whole surface; long tapering peg-like projection behind nucleus with twisted fleshy extremity.

TYPE LOCALITY: Tosa Bay, Shikoku, Japan.

DIMENSIONS: Holotype, max. diam. 26.1 mm, alt 10.5 mm. Max. size approx. 28 mm x 12 mm, 6½ whorls.

LOCATION OF TYPE: National Science Museum, Tokyo, Japan. Reg'd No. not ascertained.

DISTRIBUTION: Only recorded in Australia from Cape Moreton area in southern Queensland (27° 02′ S., 153° 28′ E). No records are available for any intermediate localities between Australia and Japan.

MATERIAL: 1 specimen N.E. of Cape Moreton, southern Queensland, 114-124 metres, ex T. A. Garrard coll, A.M. No. C.91663. 1 specimen same locality and donor (taken alive), A.M. No. C.68518 (Both specimens trawled by D. Harris, Yeppoon, Q.) 1 specimen off Moreton Bay, southern Queensland (27° 27′ S., 153° 39′ E.), 77 metres, coll W. F. Ponder 29/3/69, H.M.A.S. *"Kimbla"*, A.M. No. C.77065 (live specimen). A.M. total 3 specimens.

DISCUSSION: Habe mentions that this species has four equidistant grooves on each whorl in addition to a peripheral groove, but this is at variance with the 7-8 grooves on Queensland specimens; also the radial striations are mentioned as fading on the body-whorl, but Queensland specimens show the radial striations becoming coarser and bolder on the body-whorl; a basal peripheral groove is also mentioned but not the number of other grooves on Queensland specimens; also the 18-20 crenulations on umbilical cord contrast with 28 on Queensland specimens. Although it has not been possible to obtain any Japanese specimen for comparison, there is little doubt that the Queensland specimens are conspecific. The differences noted above are probably only ecological variations, and may be due to the possibility that the Australian and Japanese populations have become disjunct over a long period of time, especially as no records of intermediate locality occurrences can be found.

FOSSIL SPECIES

Architectonica (Discotectonica) balcombensis Finlay, 1927 Fig. 6 (6-8), 10 (7-9).

Solarium acutum Tenison-Woods, 1879:236, pl. 21, fig. 11.
Architectonica balcombensis Finlay, 1927a:501 (New name for *Solarium acutum* Tenison-Woods, 1879, non Conrad, 1860).
Architectonica (Discotectonica) balcombensis. – Marwick, 1931:101.

DESCRIPTION: *Protoconch* regularly coiled, varying .60-.80 mm diam. *Teleoconch* flatly depressed, up to 6½ flatly convex whorls in width of 32 mm, base convex, periphery acute. *Sutures* finely incised, joined to base of peripheral keel. *Sculpture* of up to 9 flatly-rounded narrow spiral cords, flatly gemmate, some with fine threads between, followed by peripheral edge, which is strongly crenulate and often bifid in later stages; base concave next to periphery, balance convex with a number of spiral grooves, and flattened obliquely striated cords of various widths; 2-3 wide flattened cords of axially ridged nodules adjoin umbilicus. *Umbilicus* widely perspective, average 37% of shell diam. at maturity, bounded by strong obliquely crenulated cord, becoming rougher and more irregular with age, spirally striated by 6-7 microscopic grooves and/or threads; umbilical canal with flat base, strongly obliquely striated. *Aperture* narrowly ovate,

contracted to point at outer margin, narrow groove at base of inner-lip, which is sharply inclined to right basally. *Colour* – many specimens retain an overall light brown coloration.

TYPE LOCALITY: Lower beds, Muddy Creek, west of Hamilton, Victoria, 6.4 km Muddy Creek Formation: Balcombian: Middle Miocene.

DIMENSIONS: Lost holotype, max. diam. 6 mm, alt. 1.5 mm. Largest specimen examined max. diam. 32 mm, min. diam. 28.1 mm, alt. 12 mm, 6½ whorls. Proposed neotype, max. diam. 17.5 mm, min. diam. 16.5 mm, alt. 7.0 mm

LOCATION OF TYPE: Holotype should have been lodged with A.M., Sydney with a number of other specimens from the Tenison-Woods coll, but register does not show it as having been received, and it must be presumed lost. The species now described and figured has been accepted by authors for many years as the *"Solarium acutum"* of Tenison-Woods — it agrees well with his description, explanatory notes and figure, and some of the older specimens held by A.M. and N.M.V. and marked as such go back to the year 1888. However, as the original description of *A. (Discotectonica) squamogranosa* Chapple, 1941, takes into account its close relationship with *A. (D). balcombensis* Finlay, it is necessary in order to avoid future confusion and doubt regarding the identity of the two species, to designate a neotype for *A. (D). balcombensis.*

Accordingly in compliance with Article 75 of the I.C.Z.N. I hereby designate a neotype for the species named as *Solarium acutum* Tenison-Woods, 1879 (=*Architectonica balcombensis* Finlay, 1927) and submit the following reasons:

1. No other Australian Tertiary fossil species in the genus *Architectonica* possesses the acute peripheral keel and concave basal area adjoining, with the exception of *Architectonica (Discotectonica) squamogranosa* Chapple, 1941. The author's remarks in English following the Latin description state "each whorl margined with broad granular lines, 2 or 3 in number, the central one where there are 3 being much smaller," fits the proposed neotype and all other specimens examined.

2. The data and description of the species as above are sufficient to ensure recognition of the specimen designated as neotype without difficulty.

3. A thorough search has been made in all fossil and related Recent material in the Australian Museum, Sydney, also in all relevant fossil material at the National Museum of Victoria, Melbourne, but no trace can be found of any specimens which can be connected in any way with material owned by the original author; the holotype and any related material must therefore be presumed lost.

4. It is considered that the neotype is consistent in all respects with the original description, also the author's explanatory notes and the illustration; it also agrees in all respects with other specimens held by the Australian Museum and received as early as 1888, marked as *Solarium acutum* and from the type locality.

5. The neotype is from the same locality and same geological horizon as the holotype, viz., the lower beds of "Clifton Bank," Muddy Creek, 6.4 km west of Hamilton, Victoria. (Muddy Creek Marl: Balcombian: Middle Miocene). Collected by F. A. Cudmore, 1922.

6. The neotype is the property of the National Museum of Victoria, Melbourne, Victoria, Fossil Dept., Reg'd No. P. 34820, where it is housed in a research collection and available for study at all times.

MATERIAL: A.M. Fossil Beach, Mornington Peninsula, Victoria. Grid ref. Cranbourne 072,845. Balcombe Clay: Balcombian: Middle Miocene. 35 specimens (3 lots), A.M. Nos. C. 74895 (28 specs), F. 1932 (6 specs), F. 814 (1 spec.).

Cliff-face S. of Grice's Creek, Mornington Penin., Victoria. Grid Ref. Cranbourne 106,903. Upper Balcombe Clay: Bairnsdalian: Middle Miocene. 2 specimens (1 lot), A.M. No. C. 94482. Muddy Creek, near Hamilton, Victoria. Muddy Creek Formation:Balcombian: Middle Miocene. Topotypes. 4 specimens (2 lots), A.M. No. C. 94483 (3 specs), F 732 (1 spec.).

River Murray Cliffs, near Morgan, S. Australia. Cadell Marl Lens of Morgan Limestone: Batesfordian: Lower Miocene. 5 specimens (1 lot), A.M. No. C. 94484.

N.M.V. Clifton Bank, Muddy Creek, near Hamilton, Victoria. Topotypes. 6 specimens (1 lot); N.M.V. No. P. 31315. 16 topotypes (1 lot) N.M.V. No. P. 31318.

Total specimens examined, A.M. 46 specimens (7 lots), N.M.V. 22 specimens (2 lots), total 68 specimens (9 lots).

DISCUSSION: This species and its two congeners in the subgenus *A. (Discotectonica)* apparently became extinct in the late Miocene, in the form in which they then occurred. Whether the northern *A. (Discotectonica) acutissima* Sowerby is a surviving descendant is open to conjecture, but as shown under "Discussion" following that species there are certain points of resemblance. For differences between *A. (Discotectonica) balcombensis* and *A. (D). squamogranosa,* see notes following description of the latter.

Architectonica (Discotectonica) squamogranosa Chapple, 1941. Fig. 10 (24-25)

Architectonica (Discotectonica) squamogranosa Chapple, 1941:123, pl. 14, fig. 1.

DESCRIPTION: *Protoconch* regularly coiled, varying .68-.71 mm diam. *Teleoconch* depressed conoid, 5½ whorls in diam. of 32 mm, convex dorsally, concave section on base adjoining peripheral keel, balance flatly convex. *Sutures* finely incised, joined at base of peripheral keel. *Sculpture* of 5 flattened cords, including peripheral keel, dissected into broad flattened nodules by numerous oblique axial grooves; sculpture on base consists of one narrow raised cingulum, separated from peripheral keel by broad sulcus, in which one or two threads are present; balance of base separated from umbilical cord by a pronounced deep narrow sulcus; numerous axial folds radiate from the sulcus, fading towards periphery. *Umbilicus* wide and perspective, averaging 37% of shell diam. at maturity; umbilical cord wide and strongly crenulate; suture joined away from groove, leaving part of folded area visible through umbilicus; umbilical canal wide, flat-based, with numerous axial growth lines. *Aperture* ovate, contracted at periphery, inner-lip arcuate, outer-lip thin and simple.

TYPE LOCALITY: Lower beds, Muddy Creek, west of Hamilton, Victoria. Muddy Creek Formation: Balcombian: Middle Miocene.

DIMENSIONS: Holotype, max. diam. 19 mm, alt 8 mm. Maximum size 25 mm x 10 mm, 5½ whorls.

LOCATION OF TYPE: N.M.V., Melbourne, Fossil Dept., coll E. H. Chapple, No. F. 14102.

MATERIAL: 2 specimens from Clifton Bank, Muddy Creek, coll F. A. Cudmore 1922, N.M.V. No. P. 31317. 4 specimens from Clifton Bank, Muddy Creek, coll F. S. Colliver, N.M.V. No. P. 31316.

DISCUSSION: This species differs from *A. (Discotectonica) balcombensis* by the deep and sharply cut sulcus surrounding the umbilical cord, and the strong cingulum on base close to the peripheral keel, also lack of any spiral grooves between sulcus and periphery; the broad flattened segmented cords on dorsum contrast with the narrower more numerous and flatly gemmate cords in *A. (D). balcombensis*.

Architectonica (Discotectonica) sp. Fig. 10 (16-18)

DESCRIPTION: *Protoconch* 1½ whorls, white, slightly inflated, smooth and shining, .75 mm diam. *Teleoconch* depressed, 3½ flat-topped whorls in diam. of 11.5 mm, base convex, strong crenulated peripheral keel. *Sutures* finely incised, joined immediately below edge of peripheral keel, whorls not imbricating. *Sculpture* of 5 broad flatly crenulated spiral cords, outermost separated from peripheral keel by a fine gemmate thread which commences after first 1½ whorls; whole dorsal surface crossed by rough and irregular growth lines and a number of microscopic spiral threads on top of cords; base with 10 flatly crenulated cords between peripheral keel and a strongly crenulated umbilical cord, the whole crossed by numerous microscopic spiral threads and rough growth lines. *Umbilicus* wide and perspective, 33% of shell diameter at maturity, with microscopic spiral striations on the crenulated umbilical cord, both over-riding and between the crenulations; broad umbilical canal is flat-based, with a central strongly crenulated cord similar to umbilical cord. *Aperture* broadly ovate, peaked towards peripheral keel; inner-lip arcuate, scarcely reflected.

LOCALITY: Just below high-tide mark, east side of North Arm, below Ferndale Parade, Lakes Entrance, Victoria. Grid ref Bairnsdale 913,276. Jemmy's Point Formation: Cheltenhamian: Upper Miocene.

DIMENSIONS: Max. diam. 11.5 mm, min. diam. 10 mm, alt 4.9 mm, 3½ whorls.

LOCATION OF SPECIMEN: N.M.V., Melbourne, Victoria, Fossil Dept. Reg'd No. P. 31319. Pres. Mrs. M. Griffiths, Lakes Entrance, Victoria, 2/1973.

MATERIAL: Single specimen only as above.

DISCUSSION: This third species in the subgenus, unfortunately a unique specimen, has only one feature in common with the type for the subgenus, *A. (Discotectonica) balcombensis* Finlay, apart from the sharp peripheral keel, that is the "broad granular lines" at the margin, the central being the smallest; however, it differs in having flat rhomboid segments composing the main dorsal cords in lieu of fine prickly nodules, it has no concave peripheral area, the base being convexly rounded, and only half the number of basal cords with no fine threads; also the umbilical cord is composed of regular and even roundly-pointed crenulations in place of the broad but narrowly ridged and sharp-ended crenulations in *A. (D). balcombensis*.

Subgenus *SOLATISONAX* Iredale, 1931:229. Type species by original designation *Solatisonax injussa* Iredale, 1931.

References: Wenz, 1938-44:671.

DIAGNOSIS: Medium size, dull, roundly and bluntly medium conical; wide-angled but sharply-edged periphery; deep narrow umbilicus; almost smooth in general appearance; periumbilical nodules tending to disappear at maturity; thin fawn periostracum; no anal keel on protoconch.

Architectonica (Solatisonax) injussa (Iredale, 1931). Fig. 4 (13-15).

Solatisonax injussa Iredale, 1931:229, pl. 25, figs 7, 8.
Philippia injussa. – Bayer, 1942:7.

DESCRIPTION: *Protoconch* regularly coiled, varying .94-1.15 mm diam. *Teleoconch* roundly conical, 6 flatly convex whorls in width of 31 mm, slightly concave dorsally near peripheral keel; base convex. *Sutures* finely incised, joined to base of peripheral keel. *Sculpture* of one central cord of fine elongate nodules, which coalesce on body-whorl; several fine spiral striae on either side of nodules, of varying strengths, the whole crossed by numerous oblique growth lines, which also extend across base. *Umbilicus* perspective but narrow, average 30% of shell diam. at maturity; umbilical cord with small blunt crenulations, tending to fade out with maturity; two barely perceptible flattened periumbilical cords; umbilical canal with convex base, obliquely wrinkled. *Aperture* sub-rhomboid, inner-lip inclined to right at base; outer and basal lip thin and simple. *Colour* dull pale fawn with few oblique darker streaks; light tinge of same colour on umbilical crenulations; thin fawn periostracum. *Operculum* circular, deeply concave, central nucleus, amber in colour, transparent at edges; composed of extremely thin layers of chitinous material; about 20 ragged concentric growth marks on upper surface, 6-7 equal sized layers at periphery; total thickness when dry no more than .5 mm.

TYPE LOCALITY: Between Gabo and Flinders Islands, Bass Strait, 183 metres. Author's original label states "100 fathoms off Gabo Island," which is taken to be approx. 38° S., 150° E.

DIMENSIONS: Holotype, max, diam. 25 mm, alt 14 mm. Max. size 31 mm x 18 mm, 6 whorls.

LOCATION OF TYPE: A.M., Sydney, No. C.57776.

DISTRIBUTION: Off Newcastle, New South Wales (32° 56′ S., 151° 56′ E.), to eastern Bass Strait, in depths ranging from 137 to 366 metres. There are no known records from outside this area and apparently an endemic species.

MATERIAL: 1 specimen E. of Newcastle as above, 285-292 metres, coll A. A. Racek 2/7/59 ex "*Challenge*" trawl No. 318, A.M. No. C.63614. 2 specimens off Broken Bay, New South Wales (33° 33′ S., 151° 20′ E.), 137 metres, ex T. A. Garrard coll ex "*Challenge*," A.M. No. C. 91662. 1 specimen S. of Gabo Island, Victoria, "*Endeavour*" 1912, 366 metres, No. E.5590. 1 specimen between Gabo and Flinders Islands, Bass Strait (approx. 39° S., 149° E.), 183 metres, pres. Fisheries Bureau, A.M. No. C.69057.

F.R.V. "*Kapala*" 7/1975, 366 metres E. of Stanwell Park, New South Wales, Stn. 75-05-01, A.M. No. C. 100604, 12 specimens. 366 metres as above, A.M. No. C.100603, 3 specimens (live). 8/1975, 457 metres E. of Port Kembla, New South Wales, Stn. 75-05-06, A.M. No. C. 100864, 1 specimen. 412 metres E. of Port Kembla, Stn. 75-05-07. A.M. No. C.100865, 24 specimens. 457 metres E. of Port Kembla, Stn. 75-05-09, A.M. No. C.100866, 3 specimens. 16/12/75, 412 metres E. of Kiama, New South Wales, Stn. 75-12-05, A.M. No. C.102734, 17 specimens. (One specimen possesses a strong narrow raised cingulum on base 2 mm in from periphery).

Total specimens A.M. 66 (11 lots).

DISCUSSION: This species cannot be confused with any other in the family, being readily recognisable by the roundly conical formation, dull surface, and small umbilicus almost devoid of ornamentation at maturity. As shown under "Material" this species was very rare until commencement of dredging by F. R. V. "*Kapala*" in July and August 1975,

when 60 further specimens were acquired, 3 being live with opercula. The specimen from Stn. 75-05-06 is an aberrant one, with dorsum almost flat and umbilicus widely expanded and perspective.

Architectonica (Solatisonax) atkinsoni (E. A. Smith, 1891). Fig. 4 (7-9).

Solarium atkinsoni E. A. Smith, 1891:441, pl. 35, fig. 19.
Architectonica atkinsoni. — Iredale, 1941:228-9.
Philippia atkinsoni. — Bayer, 1942:1.

DESCRIPTION: *Protoconch* regularly coiled but inflated and prominent, varying .94-1.17 mm diam. *Teleoconch* depressed conic, 3¼ whorls in diam. of 7.5 mm, flatly convex dorsally and on base, but with narrow concave section adjoining periphery on dorsum. *Sutures* joined below periphery, finely incised, whorls slightly imbricating. *Sculpture* of one fine granulated cord in centre of first whorl, "drifting" towards periphery in second whorl, then becoming flattened and obscure; a peripheral ridge commences simultaneously with above cord, crenulated on first two whorls and becoming flatter and irregular in shape; fine to coarse oblique growth lines cross all whorls; 2 to 9 fine spiral grooves on all whorls, area between grooves flatly rounded, area adjacent to periphery is concave; base with 9-14 fine cords and threads between periphery and umbilicus. *Umbilicus* perspective, average 37% of shell diameter at maturity, bordered by cord with rough and uneven blunt crenulations; umbilical canal with convex base crossed by crowded oblique growth lines. *Aperture* sub-triangular with grooves inside peripheral keel and at base of inner-lip; outer-lip thin, straight and simple; inner-lip below parietal wall curves obliquely to right. *Colour* pale straw with a few indistinct pale fawn maculations. *Operculum* not available.

TYPE LOCALITY: 750 metres off Sydney, New South Wales ("*Challenger*" Stn. 164B.)

DIMENSIONS: Holotype, max. diam. 7.5 mm, min. diam. 6.5 mm, alt. 4 mm. Largest specimen examined is identical with measurements of holotype with 3¼ whorls.

LOCATION OF TYPE: B.M.N.H. Reg'd. No. 1899:10:12:41.

DISTRIBUTION: From south coast of Western Australia between Eucla and Esperance (31°43′ S., to 33°51′ S., 121°53′ E. to 128°52′ E.), 79-147 metres. Eastwards through South Australia, Victoria and northwards to 35 km E. of Narrabeen, New South Wales, north of Port Jackson (33°39′; S., 151°17′; E.), 146 metres. Least depth recorded, 73 metres off 90 Mile Beach, Victoria; greatest depth apart from holotype, 457 metres 37 km E. of Port Jackson, New South Wales. No known records outside these boundaries and apparently an endemic species.

MATERIAL: Eucla-Esperance as above, 2 specimens coll C.S.I.R.O. 5-9/7/62, H.M.A.S. "*Gascoyne*" (G2/96-97/62), A.M. No. C. 92966. E. of Narrabeen as above, 4 specimens coll Prof. Haswell, A.M. No. C. 25832. Least depth as above off 90 Mile Beach, 1 specimen N.M.V. No. F. 27942. Greatest depth as above off Port Jackson, 2 specimens coll W. F. Petterd, A.M. No. C. 24480. Total specimens from A.M., N.M.V., S.A.M. and W.A.M. 41 (21 lots).

DISCUSSION: This species bears a resemblance to the much larger *A. (Solatisonax) injussa* Iredale as it would be in its early stages, although no immature specimens of that species have been observed. The within species differs however in having the central granulated cord on the first whorl "drifting" towards the periphery in the second whorl, then becoming flattened and obscure; in *A. (S). injussa* the central cord remains in the centre of each whorl throughout, and that species grows to 31 mm max. diam. with 6

whorls. An equivalent 3¼ whorls in *A. (S). injussa* would measure 10 mm diam., in comparison with 7.5 mm diam. in the holotype of *A. (S). atkinsoni* also with 3¼ whorls, although the protoconchs of the two species are of equal diameter.

Genus *PHILIPPIA* Gray, 1847

Subgenus *PHILIPPIA* Gray, 1847:146. Type species by original designation *Solarium luteum* Lamarck, 1822.

REFERENCES: Adams, 1858:243; Chenu, 1859:233; Tryon, 1887:5; Wenz, 1938-44:670; Bayer, 1942:1; Suter, 1913:316; Robertson, 1963:12; 1970:66; 1973:37.

DIAGNOSIS: Small, roundly conical, small protoconch, two widely spaced peripheral keels, only one crenulated umbilical cord, other sculpture negligible. (The only species recorded from Australia in this subgenus possesses an anal keel on the protoconch).

Philippia (Philippia) lutea (Lamarck, 1822). Fig. 5 (13-18).

Solarium luteum Lamarck, 1822:5. — Deshayes, 1830:159, no. 5; Kiener, 1839:9, pl. 4, fig. 9; Deshayes, 1843:100; Philippi, 1853:31, pl. 1, figs 10, 11; pl. 4, fig. 11; Reeve, 1864, sp. 14; Angas, 1867:201.

Philippia lutea. — Adams, 1858:243, pl. 25, fig. 8; Gray, 1847:146; Cotton and Godfrey, 1933:72, pl. 1, fig. 1; Powell, 1937:75; Bayer, 1942:12; Macpherson and Gabriel, 1962:100, fig. 126.

Solarium (Philippia) luteum. — Chenu, 1859:233, fig. 1355; Hanley (Sowerby), 1863:237, pl. 4, figs 53, 54; Marshall (Tryon), 1887:16, pl. 5, figs 71, 72.

Architectonica (Philippia) lutea. — Suter, 1913:316, pl. 46, fig. 4.

DESCRIPTION: *Protoconch* inflated but small, smooth and shining, varying .82-.94 mm diam., with short anal keel. *Teleoconch* roundly conical, 5 smooth convex whorls in width of 15 mm, base convex. *Sutures* finely incised, joined between two peripheral keels. *Sculpture* consists of only a few vague spiral striations crossed by faint growth lines, and one flatly-rounded keel above sutures, two on periphery of body-whorl; base also has a few vague spiral striations crossed by faint growth lines. *Umbilicus* very small and deep, averaging 15% of shell diam. at maturity, only one periumbilical cord with white closely packed irregular pointed crenulations; umbilical canal with strongly wrinkled convex base. *Aperture* almost circular, with flattened top forming base of penultimate whorl; outer-lip thin and simple. *Colour* deep cream, yellow ochre, light or deep grey, or deep red-brown, with one row of fine purple-brown spots on white band on keel above suture, a further similar row beneath sutures. *Operculum* amber, very thin, chitinous, pauci-spirally coiled counter-clockwise externally, sub-central nucleus, dome-shaped knob on inner surface behind nucleus.

TYPE LOCALITY: "Seas of New Holland" (Lamarck).

DIMENSIONS: Holotype, diam. 12 mm, alt 9 mm. A fully grown specimen measures 15 mm x 10 mm with 5 whorls.

LOCATION OF TYPE: Museum d'Histoire Naturelle, Geneva, reg'd number not ascertained.

DISTRIBUTION: In Western Australia, furthest north Vansittart Bay (14°03′ S., 126°17′ E.), southwards along W. Australian coast, through S. Australia, Victoria, Tasmania

(Granville Harbour west coast — 41°48′ S., 145°00′ E.), along north coast and southwards along east coast to Recherche Bay (43°33′ S., 146°55′ E.); in New South Wales northwards to Woolgoolga (30°07′ S., 153°12′ E.) Inter-tidal to 82 metres, greatest depth recorded. Also occurs in North Island of New Zealand.

MATERIAL: Vansittart Bay as above, 2 specimens coll W. Burrows 12/11/67, A.M. No. C. 45203. Woolgoolga as above, 1 specimen coll J. Kerslake, A.M. No. C. 91661. Greatest depth as above, 1 white specimen in fine condition 82 metres off Port Hacking, New South Wales (34°03′ S., 151°11′ E.), ex T. A. Garrard coll, A.M. No. C. 91660. Total specimens examined from all Australian Museums 518 (103 lots).

DISCUSSION: This species in its early stages, usually up to 2-2½ whorls, possesses even and regularly spaced crenulations round the umbilicus, not crowded and mis-shapen as they usually become towards maturity; in addition a number of heavy and evenly spaced ridges are present, radiating from umbilicus to periphery, which usually disappear entirely or almost so at maturity.

The species appears to be identical or almost so with *Philippia hybrida* (Linnaeus) from the Mediterranean, and possibly spread from there originally. Bayer (1942:13) attempted to explain a few small differences between the two species but his remarks are not convincing. A tremendous variation occurs in *Philippia lutea* in Australia as regards colour pattern, height/width ratio, etc., and the family is noteworthy for its occurrence in widely disjunct areas in identical or closely similar forms. However proving this point is not important so far as this revision is concerned, and the two names may be allowed to remain.

The species varies greatly in Australia, east coast specimens being invariably elevated conic and coloured yellow ochre or light buff, a few specimens light grey; in Victoria light and dark grey specimens predominate, whilst in South Australia a red tinge makes its appearance and the shells become more depressed, the height/width ratio decreasing from 70-80% to 60-70%; in Western Australian specimens the shells become so depressed that the ratio decreases to 45-55%, the bulk of specimens examined being light to deep blackish-red in colour.

Subgenus *PSILAXIS* Woodring, 1928:7, 355. Type species by original designation *Architectonica (Philippia) krebsii* Morch.

REFERENCES: Wenz, 1938-44:671; Robertson, 1970-75; Robertson Scheltema and Adams, 1970:55-65.

DIAGNOSIS: Larger than *Philippia* s.s. but more flatly rounded, larger protoconchs; one prominent peripheral keel with a smaller cingulum above and below; two crenulated periumbilical cords, inner heavy and irregularly wrinkled, outer smaller with small irregular nodules; generally smooth and polished. (The two Recent species recorded from Australia in this subgenus possess an anal keel on the protoconch, but not the one new fossil species described).

Philippia (Psilaxis) oxytropis A. Adams, 1854. Fig. 5 (19-24).

Philippia oxytropis A. Adams, 1854:317. — Bayer, 1942:14.

Solarium (Philippia) oxytropis. — Hanley (Sowerby), 1863:236, pl. 4, figs 46, 47; Marshall (Tryon), 1887:15, pl. 5, figs 65, 66.

Solarium oxytropis. — Reeve, 1864:pl. 3, fig. 15.

Philippia manifesta. — Iredale, 1931:229, pl. 25, figs 9, 10 (not 19, 20).

Philippia (Psilaxis) oxytropis. — Robertson, 1970:66-83, text figs.

DESCRIPTION: *Protoconch* smooth and shining, small but inflated, varying 1.33-1.66 mm diam., with long brown anal keel. *Teleoconch* depressed, 4½ flatly convex whorls in diam. of 12.5 mm, convex base. *Sutures* finely incised, joined at centre of peripheral keel. *Sculpture* consists of a prominent smooth peripheral cord with one narrow cingulum above and one below; microscopic growth lines on all whorls; umbilical cord heavy with fine crowded crenulations, surrounding which is a further more finely crenulated cord, separated by a deep fine sulcus from a cord of prominent axially ridged nodules. *Umbilicus* small but perspective, averaging 27% of shell diameter at maturity; umbilical canal flat based and strongly axially striated. *Aperture* roundly triangular, two fine grooves inside peripheral keels, deep groove below inner-lip for short distance; outer-lip thin and simple. *Colour* medium brown with white triangular spots on peripheral keels, also on outer periumbilical cord and occasionally on the main cord. *Operculum* chitinous, mid-brown, concave, thin and frail, central nucleus, showing extremely fine concentric ridging in places; yellow mushroom-shaped knob, constricted basally, at rear of nucleus.

TYPE LOCALITY: New Caledonia.

DIMENSIONS: Holotype, none given. Largest specimen examined measures 19 mm max. diam., 12.5 mm alt., 4½ whorls (Sydney Harbour dredgings).

LOCATION OF TYPE: Should be with B.M.N.H. but unable to be located.

DISTRIBUTION: On west coast, 160 km N.W. of Broome, Roebuck Bay (16°58′ S., 120°47′ E.), to bay north of Point Cloates (22°37′ S., 113°38′ E.) and southwards to Shark Bay (25°30′ S., 113°30′ E.) On east coast, Michaelmas Cay, north Queensland (16°36′ S., 145°59′ E.), southwards along Queensland and New South Wales coasts to 19 km S. of Montague Island, New South Wales (36°15′ S., 150°13′ E.) Distribution generally apart from Australia is northern New Zealand, Lord Howe Island, New Caledonia, Cook Islands, Hawaiian Islands and Japan, also one small restricted area at head of Red Sea.

MATERIAL: N.W. of Broome as above, 2 immature specimens, 194 metres (greatest depth recorded), coll. B.M.R. 29/11/67, M.V. *"Kos 2"* (K67-248), A.M. No. C.94221. Point Cloates as above, 1 specimen *"Ningaloo"* Exped 30/8/68, W.A.M. No. 125-73. Shark Bay as above, 1 specimen trawled P. Wood 1963, W.A.M. No. 128-73. Michaelmas Cay as above, 1 specimen ex T.A. Garrard coll, A.M. No. C.91668. Montague Island as above, 1 specimen ex L. Woolacott coll, 119 metres, A.M. No. C.91669. Total specimens examined from all Australian Museums 127 (34 lots).

DISCUSSION: This species can be separated from the other Indo-Pacific species *P. (Psilaxis) radiata* (Roeding) to a certain extent by its overall coloration with small white tent shaped markings at the sutures, but more definite differences in the umbilicus and protoconch are described under "Discussion" following the description of *P. (P). radiata*.

Philippia (Psilaxis) radiata (Roding, 1798). Fig. 3 (10-18).

Architectonica radiata Roding, 1798:79, no. 1027.
Solarium cingulum Kiener, 1838:6, pl. 3, fig. 6. — Chenu, 1859:232, fig. 1351; Reeve, 1864, pl. 3, fig. 19; Sowerby, 1892:28.

Solarium (Philippia) cingulum. — Hanley (Sowerby), 1863:237, pl. 4, figs 55, 56; Marshall (Tryon), 1887:15, pl. 5, figs 63, 64.

Philippia layardi A. Adams, 1854:317; Angas, 1871:92; Bayer, 1942:8.

Architectonica layardi. — Hedley, 1917:101.

Philippia stipator Iredale, 1931:229, pl. 25, figs 17, 18.

Philippia radiata. — Kuroda, 1941:86, no. 205; Rippingale and McMichael, 1961:63, pl. 6, fig. 22; Wilson and Gillett, 1971:34, pl. 13, fig. 13; Bayer, 1942:15.

Philippia (Psilaxis) radiata. — Robertson, 1970:66-83, text figs.

DESCRIPTION: *Protoconch* smooth and shining, small but inflated, varying 1.15-1.49 mm diam., with short sharp anal keel. *Teleoconch* depressed, 5¼ flatly convex whorls in diam. of 24 mm, base convex. *Sutures* finely incised, joined at centre of peripheral keel. *Sculpture* of 2 narrow ridged cords at base of each whorl, a series of folds at top of first main whorl, all crossed by microscopic growth lines; sculpture on base consists of one flattened ridge adjoining peripheral keel, and irregularly wrinkled growth lines radiating from umbilicus. *Umbilicus* small but perspective, 18% of shell diameter at maturity, bordered by a heavy irregular crenulated cord, and a second narrower periumbilical cord with small irregular nodules; umbilical canal deep, concave base, finely obliquely striated. *Aperture* sub-circular, slight channel behind peripheral keel; inner-lip straight with two small narrow channels at base. *Colour* white with medium to dark brown band round top of whorls; spokes, axial bands or broad but narrowing radiations of colour extend from the sub-sutural band to base of whorls; base white or with narrow or broad band of pale straw colour, often fully coloured with same colour as dorsum; small outer periumbilical cord has faint small yellow-brown spots. *Operculum* chitinous, thin and frail, concave, central depressed nucleus, spiral overlapping growth marks, mushroom shaped projection at rear of nucleus.

TYPE LOCALITY: "La mer des Indies" (Kiener).

DIMENSIONS: Holotype — none given. A fully grown specimen measures 25 mm max. diam., 22 mm min. diam., 15 mm alt., 5¼ whorls.

LOCATION OF TYPE: Unknown, unable to trace.

DISTRIBUTION: Western Australia, Turtle Bay, North-West Cape (21°45′ S., 114°10′ E.), southwards to Dirk Hartog Island (25°50′ S., 113°05′ E.), East coast, Murray Island, Torres Strait (9°55′ S., 144°05′ E.), southwards along Queensland and New South Wales coasts to Port Jackson, New South Wales. Greatest depth 63-73 metres, 3 km N.E. of west side of Gillett Cay, Swain Reefs, Queensland (21°43′ S., 152°25′ E.) Appears to be mainly sub-tidal. Distribution generally from Red Sea and East Africa through Indian Ocean, northwards to Japan, southwards to Australia and New Zealand, Pacific Ocean generally to Hawaiian Islands.

MATERIAL: Turtle Bay as above, 1 specimen coll L. Figgis, Feb. 1972, A.M. No. C.86126. Dirk Hartog Island as above, 1 specimen coll B. R. Wilson, June 1957, W.A.M. No 4615 (pt). Murray Island as above, 1 specimen coll C. Hedley on beach, A.M. No C.29401. Port Jackson as above, 2 specimens ex *"Triton"* dredgings off Sow and Pigs Reef, one A.M. No. C.91664 (pt), also holotype of *P. (P). stipator* Iredale, No. C.93224. Total specimens examined from all Australian Museums 204 (77 lots).

DISCUSSION: A great deal of confusion has existed for many years in Australia regarding the identity of *Philippia radiata, P. layardi* and *P. oxytropis*, and separation appears to have been carried out chiefly by colour pattern. Examination of the many specimens from all Museums proves the contention of Robertson (1970) that only two species of *Philippia (Psilaxis)* occur in the Indo-Pacific area, being *P. (P). radiata* (Roding), extending throughout the Indian Ocean and as far as Tahiti and the Tuamotus in the central Pacific. The other species, *P. (P). oxytropis* A. Adams on present records is

confined between 113° E. on the Western Australian coast, and about 155° W., including the Hawaiian Islands and Cook Islands in the central Pacific. Disregarding the greatly variable colour patterns of the two species, *P. (P). radiata* can be separated by its very small umbilicus with irregular crenulations, averaging 14% of shell diameter at maturity, compared with 27% in *P. (P) oxytropis*; also a smaller protoconch, varying from 1.15-1.49 mm diam., compared with 1.33-1.66 mm in *P. (P). oxytropis*; the protoconch of *P. (P). radiata* is usually all white but occasionally with patches of brown, and has a short sharp anal keel on protoconch bordered by a thin brown line; the protoconch of *P. (P). oxytropis* is almost invariably coloured brown with a white central patch, it also has a decidedly longer anal keel on the protoconch which is usually all brown, without a darker brown line beside it.

FOSSIL SPECIES

Philippia (Psilaxis) mitchellana nov. Fig. 10 (10-12).

DESCRIPTION: *Protoconch* 1½ whorls, inflated, smooth and shining, 1.54 mm diam., no anal keel *Teleoconch*. Six flatly convex whorls, dorsum low rounded convex, flatly convex basally. *Sutures* strongly incised, joined at centre of peripheral keel. *Sculpture* — strong peripheral keel, finely squarely beaded for about first two whorls, becoming smooth with age, a flatly rounded cingulum above it; balance of whorls almost smooth, traces of fine flattened spiral ridges in places, incremental growth striae microscopic; base with one strong cingulum divided from peripheral keel by a wide deep groove; irregular folds radiating axially from umbilicus but fading towards periphery. *Umbilicus* perspective, 28% of shell diameter at maturity, one strongly crenulated umbilical cord, divided from folded area by a strong narrow but deep sulcus; umbilical canal wide with slightly convex base, axial growth lines and one fine spiral striation in centre. *Aperture* ovate, contracted at periphery, short groove at base of arcuate outer-lip, no parietal fold present; outer-lip thin and simple.

TYPE LOCALITY: Right bank of Mitchell River, "Moondara" farm, Bairnsdale, Victoria, 91 metres north of first gully south of house. Rosehill Marl, Tambo River Formation: Mitchellian: Upper Miocene.

DIMENSIONS: Holotype, max. diam. 15 mm, min. diam. 13 mm, alt. 7.5 mm, six whorls, largest specimen examined and appears to be fully grown.

LOCATION OF TYPE: N.M.V., Melbourne, Victoria, Fossil Dept., Reg'd No. P.31314.

MATERIAL: Holotype as above, coll T. A. Darragh and K. Bell 2/5/1971. 2 specimens, topotypes, coll. T. A. Darragh 26/8/1969, N.M.V. No. P.31313. 1 specimen, topotype, coll T. A. Darragh and H. E. Wilkinson 10/12/1966, N.M.V. No. P. 31312.

DISCUSSION: The occurrence of a fossil *P. (Psilaxis)* species in the Victorian Tertiary is a discovery of importance. Robertson (1973:37) states: "Fossil *Psilaxis* is known from the Middle Miocene or Plio-Pleistocene of Jamaica and from the Upper Pliocene of Japan." (The Japanese species is stated to be *P. (P). radiata* Roeding). This new species, in common with other fossil species, shows one characteristic linking it with *Philippia* s.s., the lack of a second periumbilical cord. The suture is joined at centre of peripheral keel, in common with the two Recent species dealt with in this revision.

Compared with the two Recent species, *P. (P). oxytropis* and *P. (P). radiata* this new species can be separated by the complete lack of an anal keel on the protoconch, also by lack of the usual second periumbilical cord and second sulcus. A fine growth line recording the stage of early post-larval arrested growth occurs at approx. .6 of the

peripheral circumference of the first teleoconch whorl on holotype, adherent marl precludes observation on other specimens.

This new species has also been compared with 2 specimens held by A.M. of the Italian Pliocene species *Philippia (Psilaxis) simplex* (Bronn, 1827), the only differences noted being: *P. (P). simplex* has 5½ whorls in a diameter of 24 mm, therefore being a decidedly larger species; the dorsal cingulum adjoining the peripheral keel is clear cut and well defined, not fading on the adapical edge which it does in this new species; the exposed dorsal portion of the protoconch in *P. (P). simplex* measures 1.20 mm and 1.44 mm in the two specimens examined, being smaller than the measurement of 1.54 mm in this smaller new species. Apart from these minor differences the remaining features of the two species are remarkably similar.

ARCHITECTONICINAE species

"Fluxina" trochiformis Schepman, 1909, Fig. 9 (19).

"Fluxina" trochiformis Schepman, 1909:220, pl. 14, fig. 3.

Notes: The type for the genus *Fluxina* Dall (1881:52), viz. *Fluxina brunnea* Dall, 1881, has been shown by Merrill (1970:32) to be a species of *Calliostoma,* which therefore removes the genus *Fluxina* from the Architectonicidae. The within species possesses an anastrophic protoconch, and a new genus will therefore be necessary to contain it when a general revision of the Architectonicidae genera is undertaken.

DESCRIPTION: *Protoconch* extremely small, regularly coiled, smooth, shining, depressed, varying .30-.33 mm diam. *Teleoconch* smooth, shining, depressed conic, 6 whorls in diam. of 5 mm, flatly convex below suture, slightly excavated dorsally near periphery, peripheral edge thin and sharp, base of whorls also excavated near periphery; no anal keel present on protoconch. *Sutures* joined beneath peripheral edge, not impressed. *Sculpture* of microscopic curved growth lines, both dorsally and on base, a few microscopic spiral threads near periphery on base. *Umbilicus* widely perspective, 30% of shell width at maturity, free of ornamentation except for one very fine smooth cingulum round outer edge; umbilical canal flat-based and smooth. *Aperture* sub-rhomboid, outer-lip thin, smooth and sharp. *Colour* glass-like or translucent white. *Operculum* not available.

TYPE LOCALITY: *"Siboga"* Stn. 178, Ceram Sea (2°40′ S., 128°37′ 30″ E.), 835 metres.

DIMENSIONS: Holotype, max. diam. 5 mm, alt. 2.5 mm, 6 whorls. Apparently a fully grown specimen.

LOCATION OF TYPE: Amsterdam Museum, Netherlands, reg'd No. not ascertained.

DISTRIBUTION: 241 km W. of Cape Leveque, Western Australia (16°16′ S., 120°45′ E.), 330 metres. Gillett Cay, Swain Reefs, Queensland (21°43′ S., 152°25′ E.), 63-73 metres. Masthead Is., southern Queensland (23°10′ S., 151°54′ E.), 31-37 metres. Off Cape Martin, South Australia (37°30′ S., 140°01′ E.), 667 metres. 19 km E. of Cape Mistaken, Maria Is., Tasmania (42°42′ S., 148°17′ E.), 695 metres. Appears to be widely distributed in tropical to temperate waters, in depths ranging from moderate to very deep water. Extends northwards from Australia at least as far as the Moluccas and Celebes Islands.

MATERIAL: Cape Leveque as above, 2 specimens coll B.M.R. 21/11/67, M.V. *"Kos 2"* (K67-227), A.M. No. C.91761. Gillett Cay as above, 3 km N.E. of W. side, 1 specimen coll A.M. party 17-19/10/1962, A.M. No. C.91762. Masthead Is. as above, 1 specimen coll C. Hedley, A.M. No. C.19629 (pt). Cape Martin as above, 16 specimens coll C. Hedley, A.M.

No. C.91763 (pt). Off Maria Is. as above, 1 specimen coll W. F. Ponder 25/3/70, F.R.V. *"Penghana"*, A.M. No. C.97223. A.M. total specimens 21 (5 lots).

DISCUSSION: This very small species is very far removed from the genus *Architectonica,* but can only be placed in the same subfamily. A microscopic examination of the protoconch shows it to be anastrophic but not to a marked degree, the nucleus being visible when viewed through the umbilicus.

Growth lines indicate a wide, deep sub-sutural sinus on upper-lip and a similar sinus on lower-lip commencing close to periphery, but all breakages in the outer-lip dorsally are straight. All the above specimens agree well with Schepman's description and figures of the holotype, except that the cord above suture (peripheral edge) is plain and smooth, with no trace of the fine crenulations mentioned by Schepman, but as the holotype at the time was a unique specimen this small difference is probably an ecological variation or a slightly aberrant specimen. The fine rib or cingulum round the edge of umbilicus mentioned by Schepman as having a fine groove round it, shows no definite groove but only the in-turned edge of the cingulum.

Subfamily HELIACINAE

DIAGNOSIS: Light in weight, max. diam. 3-20 mm, with one exception to 30 mm; tall conic to flatly depressed, all strongly sculptured with cords, tessellated or granose; umbilicus narrow to medium width; peripheral area rounded to flatly rounded, or with double or single peripheral keel; operculum chitinous, of many layers built up to rounded cone-shape.

GENERA: On a world wide basis a revision of genera for this subfamily appears necessary, but species represented in Australia may be conveniently placed for the time being in four existing genera as under:

1. *Heliacus (Heliacus)* Orbigny, 1842. Tall to very tall, umbilicus narrow to wide, peripheral area of whorls rounded to flatly rounded.

2. *Heliacus (Torinista)* Iredale, 1936. Moderately to flatly depressed, umbilicus narrow to wide, bicarinate, interspace between keels either medium width or narrow and recessed.

3. *Heliacus (Awarua)* Mestayer, 1930. Moderately depressed, single peripheral keel, wide concave umbilical area with rows of nodules not in form of a cord.

4. *Heliacus (Claraxis)* Iredale, 1936. Depressed to flatly depressed, umbilicus narrow to wide, one sharp peripheral keel.

Authors generally have now accepted the contention of Iredale (1911:301) that the genus *Heliacus* Orbigny, 1842, should take precedence over *Torinia* Gray, which should be considered as dated 1847.

In the whole of the subfamily dealt with herein only one species, *Heliacus (Torinista) corallinus* nov., has an anal keel on the protoconch.

Genus *HELIACUS* Orbigny, 1842

Subgenus *HELIACUS* Orbigny, 1842:68. Type species by original designation *Solarium heberti* Deshayes, 1830:159.

REFERENCES: Chenu, 1859:232 *(Torinia);* Suter, 1913:317; Cotton and Godfrey, 1933:73; Wenz, 1938-44:666 *(Torinia).*

SYNONYMS: *Teretropoma* Rochebrune, 1882:249. Type species by original designation *Teretropoma perrieri* Rochebrune, 1882. *Torinia* Gray, 1847. Type species by original designation *Trochus cylindracea* Deshayes, 1843.

DIAGNOSIS: Species medium in width, 5-13 mm (with exception of *H. (H). stramineus* (Gmelin) — to 38 mm), tall to very tall, umbilicus narrow to wide, peripheral area of whorls rounded to flatly rounded, axial and spiral sculpture, beaded or tessellated; operculum of many layers of chitinous material, medium to high conical; no anal keel on protoconch in Australian species.

Heliacus (Heliacus) cerdaleus ponderi subsp. nov. Fig. 2 (10-12), 9 (7-9).

Solarium (Torinia) cerdaleum Melvill and Standen, 1903:297, pl. 20, fig. 16.

Torinia cerdalea — Bayer, 1948:10.

DESCRIPTION: *Protoconch* 2½ whorls, slightly inflated, smooth and shining, varying 1.17-1.52 mm diam. *Teleoconch* rounded elevated, 3½ flatly convex whorls in diam. of 8 mm, base roundly convex. *Sutures* impressed, at base of narrow canal. *Sculpture* — one cord below sutures of axially elongate segments, interstices between segments axially straight, followed by 3 further cords, interstices oblique; a narrow channel, occasionally carrying a very fine cord, then separates the upper segmented peripheral keel; a further similar basal keel below, more contracted, the two being separated by two very fine gemmate cords, giving peripheral area of shell a flatly rounded appearance; a further 5-6 segmented cords follow on base, last two near umbilicus far wider than others. *Umbilicus* narrowly perspective, averaging 28% of shell width at maturity, bordered by a strong obliquely crenulated cord; umbilical canal wide, base of canal strongly convex, axially folded and striated. *Aperture* sub-circular, except for protrusion of base of penultimate whorl, crenulated exteriorly by cords, a fine groove at base of inner-lip. *Colour* fawn to light brown, axial bars and spots of darker brown across top of whorls and round edge to base; deep brown in narrow sulci between spiral cords. *Operculum* composed of multiple layers of horn coloured, ragged-edged chitinous material, low-spired, not usual round cone shape and without central depression; rear attached to mollusc and not examined.

TYPE LOCALITY: Long Reef, Collaroy, near Sydney, New South Wales (33°43′ S., 151°18′ E.).

DIMENSIONS: Holotype, max, diam. 9.6 mm, min. diam. 8.3 mm, alt. 7.6 mm, 3½ whorls. Maximum size.

LOCATION OF TYPE: A.M., Sydney, Reg'd No. C.94479, and 5 paratypes Reg'd No. C. 94480.

DISTRIBUTION: West coast, 3 km S. of Cape Naturaliste, Western Australia (33°33′ S., 115°01′ E.), southwards to Bremer Bay (34°23′ S., 119°25′ E.), and Windy Harbour, Cape D'Entrecasteaux (34°50′ S., 116° E.) East Coast, Twofold Bay, New South Wales (37°04′ S., 149°54′ E.), 10 km E., 91-109 metres, which is greatest depth recorded; northwards to Byron Bay, New South Wales, (28°40′ S., 153°38′ E.). Appears to be endemic to southern Australia, but the range is disjunct as shown.

MATERIAL: Cape Naturaliste as above, 1 beach specimen coll W. F. Ponder and B.R. Wilson 3/1/72, A.M. No. C.90978; Bremer Bay as above, 1 specimen coll G. W. Kendrick 26/1/72, W.A.M. No. 87-73; Windy Harbour as above, 5 specimens coll R. Dunlop, W.A.M. No. 305-65; Twofold Bay as above, 1 specimen ex N. Buckland coll, A.M. No. C.93604;

Byron Bay as above, 3 specimens coll N. Coleman, May 1975, A.M. No. C.100776. Total specimens examined from all Australian Museums 45 (22 lots).

DISCUSSION: In some respects this new subspecies is as variable as most others in the subfamily. Its origins obviously lie with *Heliacus cerdaleus* (Melvill and Standen, 1903), however, it differs from that species consistently in the following respects:

1. The protoconch of this new subsp. is decidedly larger — 1.17-1.52 mm diam., compared with 1.04 mm in the holotype of *H. cerdaleus*.

2. It possesses 4 cords on the rounded peripheral area of the shell in lieu of only 3 in the holotype of *H. cerdaleus*. The fourth cord commences between the central and lower cords after completion of the first main whorl, as evidenced in the 4 immature specimens available; other cords have a tendency to bifurcate in places and at various growth stages.

3. The holotype of *H. cerdaleus* has a fine intermediate thread between all main cords, and none are visible in any specimen of the new subsp.

Apart from the bifurcation of various cords in some specimens, cords both on dorsum and base tend to vary both in width and number. Colour pattern is variable in depth of colour, and Western Australian specimens tend to have bars of darker colour more pronounced on dorsum. 3 specimens from Woolgoolga, northern New South Wales, all 2¾ whorls and not quite mature, show the deep brown colour in sulci separating spiral cords, as strong narrow bands of colour showing through into aperture, 14-16 in number, which are covered with white or cream overlay when full maturity is reached.

A specimen of this new subsp. from A.M. coll, Reg'd No. C.96135, was compared with holotype of *H. cerdaleus* at B.M.N.H. by Dr. W. F. Ponder, and found to agree except as stated above. The holotype is reg'd No. 1903.12.15.107, type locality Persian Gulf, Fao, on telegraph cable. See "Discussion" under *Heliacus enoshimensis* for differences between that species and *H. cerdaleus ponderi*.

This new subspecies is named for Dr. W. F. Ponder, Curator of Molluscs at A.M., Sydney, who has been of such great assistance in so many ways with the compilation of this revision.

Heliacus (Heliacus) enoshimensis (Melvill, 1891) Fig. 7 (22-25).

Solarium (Torinia) enoshimensis Melvill, 1891:411, pl. 2, fig. 12.

Torinia densegranosa Pilsbry, 1905:106, pl. 3, figs 15, 16, 17.

Torinia enoshimensis.— Melvill, 1913:317 Bayer, 1948:18; Kuroda Habe and Oyama, 1971:423, pl. 61, figs. 10, 11.

Heliacus enoshimensis — Habe, 1961:30, pl. 13, fig. 18.

DESCRIPTION: *Protoconch* regularly coiled, varying .94-1.15 mm diam. *Teleoconch* depressed, 3½ whorls in diam. of 11.5 mm, flatly convex dorsally and basally. *Sutures* deeply impressed, joined at base, or occasionally at centre, of peripheral keel. *Sculpture* of strong, broad, rounded, oblique axial ribs, 60-70 on body-whorl, dissected by 4-5 strong spiral grooves, spiral cords thus formed occasionally have one or two fine threads between; all cords carry several microscopic spiral threads; peripheral keel broad and rounded, basal cord below is narrower and more restricted, a fine thread between the two; 5-6 broad flatly-rounded cords on base, similar to those on dorsum, the last usually the widest and adjoining strongly crenulated umbilical cord. *Umbilicus* deep and

narrowly perspective, averaging 21% of shell diam. at maturity; canal with flatly rounded base, finely vertically striated. *Aperture* circular, outer-lip heavy and crenulated by cords; inner-lip vertical with shallow central groove and strongly reflected. *Colour* — alternate axial markings of fawn and white, or reddish brown and white, on dorsum, periphery and base. *Operculum* typical, roundly cone shaped, built up of thin fawn and white layers of chitinous material, with hollow top.

TYPE LOCALITY: Enoshima, Japan.

DIMENSIONS: Holotype, max. diam. 5 mm, alt. 2.5 mm. Largest specimen examined max. diam 12.1 mm, alt. 6.8 mm, 3½ whorls.

LOCATION OF TYPE: B.M.N.H., Reg'd No. 1884.4.3.10-12 (3 syntypes).

DISTRIBUTION: Woolgoolga, northern New South Wales (30° 07′ S., 153° 12′ E), and Ballina (28° 50′ S., 153° 36′ E.), and southwards to Botany Heads, Sydney, New South Wales. Apparently a sub-tidal species. Any records between Australia and the type locality in Japan are unknown.

MATERIAL: Woolgoolga as above, 1 specimen ex T. A. Garrard coll, A.M. No. C.91794, and 1 specimen coll F. H. Plant, Sept. 1966, W. A. M. No. 522-74; Ballina as above, 4 specimens ex T. A. Garrard coll, A.M. No C91793. Botany Heads as above, 3 specimens ex Hargreaves coll, A.M. No. C.96249. Total specimens examined from A.M. and W.A.M. 21 (10 lots). Also occurs at Norfolk Island, Kermadec Islands and Japan.

DISCUSSION: This species bears a resemblance to *Heliacus cerdaleus ponderi* Garrard nov., but the basal keel below the periphery is much more restricted and the shell more depressed in the within species; a very fine thread is occasionally present between the peripheral and basal keel but never as pronounced as the two cords always present in *H. cerdaleus ponderi*. In *Heliacus enoshimensis* the suture is joined to the base of peripheral keel, but in *H. cerdaleus ponderi* it is joined to uppermost of the two fine cords between peripheral and basal keels, resulting in a pronounced canal at the sutures.

Heliacus (Heliacus) hedleyi sp. nov. Fig. 9 (22-24).

DESCRIPTION: *Protoconch* small, smooth and shining, light amber, varying .65-.87 mm diam. *Teleoconch* elevated conic, 4½ flatly convex whorls in diam of 8.8 mm. *Sutures* deeply impressed, joined below dorsal peripheral keel. *Sculpture* of 4 prominently beaded cords, beads rhomboidal in shape, one fine thread between rows occasionally; two strong similar cords on periphery, with two finer cords between, peripheral area flat; base with 4 fine beaded cords and a further cord adjoining umbilical cord, of broad well separated flatly rounded nodules, almost rectangular in shape. *Umbilicus* small and deep, averaging 14% of shell diameter at maturity; umbilical cord with large coarse bluntly pointed crenulations; umbilical canal flat based, rough and uneven. *Aperture* almost circular, inner-lip glazed and strongly reflected, outer-lip sharp edged and crenulate. *Colour* white, occasional nodules on peripheral keels light fawn; aperture white, stained brown near suture, very thin light fawn periostracum. *Operculum* composed of very thin layers of light fawn chitinous material, built up to rounded cone shape with hollow centre.

TYPE LOCALITY: Port Curtis, Queensland (23° 52′ S., 151° 21′ E.), 13-18 metres.

DIMENSIONS: Holotype, max diam 8.8 mm, min diam 7.7 mm, alt 5.7 mm, 4½ whorls. Fully grown specimen.

LOCATION OF TYPE: A.M., Sydney, New South Wales, Reg'd No. C.18727.

DISTRIBUTION: Type locality only, apparently endemic to eastern Australia.

MATERIAL: Holotype and 2 paratypes, 13-18 metres, Port Curtis as above, coll C. Hedley. 1 specimen (topotype) coll T. Iredale, A.M. No. C 61483 (pt). One further topotype coll T. Iredale, forwarded overseas for comaprison with other species, lost in post.

DISCUSSION: This species is close to the description by Keen (1971:294) of *Heliacus mazatlanicus* Pilsbry and Lowe, 1932, but an anal keel on the protoconch is completely lacking. As the name implies, the above species was described from Mazatlan, Mexico.

Differences between this species and its closest congeners, *Heliacus madurensis* (Schepman) and *H. mighelsi* (Philippi) are described under "Discussion" following the descriptions of those species. This new species is named for the late Charles Hedley, in recognition of his voluminous and accurate work as Curator of Mollusca at the Australian Museum, Sydney.

Heliacus (Heliacus) madurensis (Schepman, 1909). Fig. 4 (10-12).

Torinia madurensis Schepman, 1909:222, pl. 14 fig. 4;
Bayer, 1948:29.

DESCRIPTION: *Protoconch* regularly coiled but elevated, smooth and shining, varying .55-.60 mm diam. *Teleoconch* roundly elevated, 3 roundly convex whorls, base strongly convex. *Sutures* deeply impressed at base of slight canal. *Sculpture* of 4 roundly flattened segmented cords divided by strong spiral grooves and crossed by strong oblique axial lines; 4 strong crenulated cords on periphery; base cut by fine spiral grooves, four flat inter-spaces, one row of axially raised elongate nodules adjoining a strong crenulated umbilical cord. *Umbilicus* narrow and deep but perspective, averaging 21% of shell diameter at maturity; umbilical canal with axially striated flatly convex base. *Aperture* sub-circular, crenulated exteriorly by cords, inner-lip arcuate and strongly reflected. *Colour* white, protoconch clear amber or white. *Operculum* circular, extremely thin amber chitinous base with microscopic black streaks, central portion of smaller diameter built up to rounded top with many successive layers of thin similar material, apex hollow.

TYPE LOCALITY: *"Siboga"* Stn. 51. Madura Bay, N.E. Java (7° 15′ S., 113° 36′ E.) 69-91 metres.

DIMENSIONS: Holotype, max diam 6 mm, alt 4.75 mm. (Unique specimen). Largest specimen examined max diam 7 mm, alt 5.5 mm, 3 whorls.

LOCATION OF TYPE: Amsterdam Museum, Netherlands, reg'd no. not ascertained.

DISTRIBUTION: Off Yeppoon, Queensland (23° 08′ S., 150° 44′ E.), 4 metres; southwards to Bustard Head, Queensland (24° 02′ S., 151° 46′ E.), 20 metres. Apparently sub-tidal to moderate depths. No records are available of occurrence between Australia and type locality in Java.

MATERIAL: Off Yeppoon as above, 2 specimens ex T. A. Garrard coll, A.M. No. C. 91765 (live). Off Bustard Head as above, 2 specimens ex T. A. Garrard coll, A.M. No. C. 91764 (live). A.M. 4 specimens (2 lots).

DISCUSSION: Protoconch nucleus was mentioned by Schepman as being brown; 2 specimens from off Yeppoon have brown protoconchs but 2 from off Bustard Head are white. This species resembles *Heliacus (Heliacus) hedleyi* Garrard nov., but differs in

having finer sculpture, especially in early whorls, a more elevated protoconch, and sutures joined at base of uppermost of 4 peripheral keels, imparting to the whorls a slightly stepped appearance, whilst the dorsum of *H. (H). hedleyi* is evenly and roundly elevated; the crenulations on umbilical cord of *H. (H). madurensis* are also decidedly finer than those of *H. (H). hedleyi.*

Heliacus (Heliacus) mighelsi (Philippi, 1853). Fig. 7 (7-9).

Solarium cyclostomum Mighels, 1845:22 (non *Solarium cyclostomum Menke).*

Torinia mighelsi Philippi, 1853:36, sp. 43 (New name for *Solarium cyclostomum* Mighels, non Menke, 1828); Hanley (Sowerby), 1866:240, pl. 5 figs 87, 88; Marshall (Tryon), 1887:19, pl. 6, figs 89, 90.

DESCRIPTION: *Protoconch* smooth and shining, elevated and inflated, varying .83-.98 mm diam. *Telecoconch* elevated, 3½ whorls in diam of 8 mm, convex dorsally and basally, elevated tubular coiling. *Sutures* impressed at base of narrow but deep canal. *Sculpture* of 4 heavy flattened cords, crossed by oblique narrow ridges on top, not in line with ridges on adjoining cords; outermost cord forms peripheral keel, with further basal keel below, interspace equal in width to keels; base with 5 similar narrow cords. *Umbilicus* deep and narrowly perspective, averaging 28% of shell width at maturity, with coarse irregularly crenulated umbilical cord; umbilical canal with slightly convex base crossed by crowded vertical growth lines. *Aperture* circular, sharp-edged, crenulated by cords; shallow groove at base of outer-lip; basal and inner-lip strongly reflected. *Colour* white with thin fawn periostracum. *Operculum* not available.

TYPE LOCALITY: Oahu, Hawaii.

DIMENSIONS: Holotype, max diam 7.6 mm. Largest specimen examined max diam 8 mm, min diam 6mm, alt 6 mm, 3½ whorls.

LOCATION OF TYPE: Unknown, unable to trace.

DISTRIBUTION: Wreck Reef, Coral Sea (22° 08′ S., 155° 10′ E.); 869 km E. of Gladstone, Queensland, near Kelso Bank (25° 13′ S., 159° 44′ E), and Lord Howe Island (31° 33′ S., 159° 05′ E.) From the Hawaiian type locality this species probably occurs across the Pacific to the Australian localities shown, but no other records are available.

MATERIAL: Wreck Reef as above, 1 specimen coll C. Hedley, A.M. No. C. 32402. Kelso Bank as above, 1 specimen 91 metres, coll M.V. *"Espirito Santo,"* B.M.R. Stn. E 68-504, 16/9/68, A.M. No.C 92404. Lord Howe Island as above, 1 specimen coll J. Brazier, A.M. No. C. 92405.

DISCUSSION: The differences noted between this species and *Heliacus (Heliacus) hedleyi* Garrard nov. are:

H. (H). mighelsi	*H. (H). hedleyi*
Protoconch larger and inflated .83-.98 mm diam.	Protoconch smaller, .65-.87 mm diam.
4 cords on whorls dorsally, wide space between 3rd and 4th	4 cords, all equally spaced
Sutures joined above basal keel, distinct step in coiling	Sutures joined below peripheral keel
Peripheral and basal keels closely set, one small cord between	Peripheral and basal keels widely set, two smaller cords between
Base with 5 narrow cords, umbilical cord weak with small numerous crenulations, umbilicus wider, 28% of shell diam.	Base with 5 variable cords, umbilical cord strongly crenulated, umbilicus narrower, 14% of shell diam.

The differences noted between *H. (H) mighelsi* and *H. (H). madurensis* (Schepman) are:

H. (H). mighelsi	*H. (H) madurensis*
3 cords dorsally between upper suture and peripheral keel	4 cords dorsally
Suture at centre or just above basal keel	Suture at base of uppermost of 4 peripheral cords
One small cord between peripheral and basal keels, all close-set	2 cords between peripheral and basal keels
Larger and perspective umbilicus, 28% of shell diam.	Umbilicus small and barely perspective, 21% of shell diam.

Heliacus (Heliacus) stramineus(Gmelin, 1791). Fig. 4 (1-6).

Trochus stramineus Gmelin, 1791:3575. — Wood, 1828:137, pl. 29, fig. 63.

Solarium stramineum. – Lamarck, 1822:4; Kiener, 1838-39:11, pl. 3, fig. 4; Deshayes, 1843:99.

Solarium stramineum (Trochus). — Philippi, 1853:32, p. 11, pl. 2, fig. 7.

Solarium (Torinia) stramineum. — Chenu, 1859:233, fig. 1353; Hanley (Sowerby), 1863:242, pl. 5, figs 95-97.

Torinia straminea. — Angas, 1871:92; Marshall (Tryon), 1887:19, pl. 6, figs 93, 94.

Heliacus stramineus. — Cotton and Godfrey, 1933:74.

Grandeliacus mortensenae Iredale, 1957:124, text fig. 1.

DESCRIPTION: *Protoconch* small, regularly coiled, varying .76-.82 mm diam. *Teleoconch* depressed conic, 5½ convex whorls in diam of 38 mm, base convex. *Sutures* strongly incised at base of deep narrow canal. *Sculpture* of 5 obliquely axially striated spiral cords, with larger gemmate cord above sutural channel; this gemmate cord becomes more deeply axially incised on penultimate and body-whorl, with a vertically striated channel between it and the sutural canal; on body-whorl there are 3 large axially striated cords with a finer one between central and lowest; suture is placed immediately below small central cord; sculpture of base consists of 3 narrow cords, each followed in turn by a broad flattened cord, then 2 more broad cords, and finally the main cord bordering umbilicus; all cords and interstices from protoconch across top of shell and underneath to umbilicus are crossed by numerous fine raised striations. *Umbilicus* broadly perspective and deep, averaging 31% of shell diameter at maturity; umbilical cord with close packed axial crenulations; umbilical canal wide and shallow, convex base, 3 spiral ridges, finely obliquely striated. *Aperture* very large and almost circular, entire lip crenulated by cords; inner-lip arcuate with narrow groove at base. *Colour* creamy-fawn or deeper orange-fawn. *Operculum* of many layers of rough and uneven circular chitinous material, built up to rounded cone shape with central nucleus and typical of the sub-family; a twisted peg-like projection at rear attached to foot of mollusc.

TYPE LOCALITY: Tranquebar, southern India.

DIMENSIONS: Holotype, none given. Largest specimen examined max diam 38.2 mm, min diam 30.5 mm, alt 27mm, 5½ whorls.

LOCATION OF TYPE: Unknown, unable to trace.

DISTRIBUTION: East coast, Buchan's Point near Cairns, north Queensland (16° 44′ S., 145° 40′ E.), southwards to N.E. of Cape Moreton, southern Queensland (27° 02′ S., 153° 28′ E.), 114-124 metres (greatest depth recorded). Shallow to moderately deep water. Occurs in eastern tropical Indian Ocean to northern Australian coastline and northwards to Philippine Islands and Japan.

MATERIAL: Buchan's Point as above, 1 specimen ex J. Kerslake coll, A.M. No. C. 92034.N.E. of Cape Moreton as above, 1 specimen ex J. Kerslake coll, A.M. No. C.92033. Total specimens examined from all Australian Museums 13 (11 lots).

DISCUSSION: This large species cannot be confused with any others in the sub-family Heliacinae, reaching 3 times the size and more of any other species, with an equal number of whorls, and is also a rich unicoloured species devoid of other markings.

The species figured by Habe (1961:31, pl. 14, fig. 1) as *H. (H) stramineus* has been omitted form the synonymy, as it is apparently only 23 mm diam in lieu of about 38 mm with the same number of whorls; in addition it has much more resemblance to a large secimen of *H. (Torinista) dorsuosus* (Hinds), and unfortunately a specimen of this species has not been available from Japan.

Heliacus (Heliacus) trochoides (Deshayes, 1830)

Solarium trochoidea Deshayes, 1830:160.

No records were held by any Australian Museum of the occurrence of this species in Australia up to the time of completion of this manuscript. However since then two

specimens have been sent to the author by a collector in Perth, Western Australia, one from North-West Cape, Western Australia (21° 47′ S., 114° 10′ E), and the other from Rottnest Island, Western Australia (32° S., 115° 30′ E.). It is not possible to give a description or figure of the species at this stage, and this note is made for record purposes.

Heliacus (Heliacus) variegatus (Gmelin, 1791). Fig. 7 (13-18).

Trochus variegatus Gmelin,1791:3575. — Wood, 1828:137, pl. 29, fig. 59.

Trochus areola Gmelin, 1791:3575. — Deshayes, 1843:100; Bayer, 1948:20.

Solarium variegatum. — Lamarck, 1816, pl. 446, fig.6; Lamarck, 1822:4; Sowerby (1820-25) 1831, no. 38, pl. 202; Kiener, 1838-39:10, pl. 4, fig. 7; Gray, 1874, Pl. 41, figs 3, 4.

Torinia variegata. — Adam, 1858:245, pl. 25, fig. 7. — Fischer, (1885) 1887:714, fig. 484; Marshall (Tryon), 1887:16, pl. 5, fig. 76; Hedley, 1907:483; 1909:360; Wilson and Gillett, 1971:34, pl. 13, fig. 15; Bayer, 1948:23.

Solarium (Torinia) variegatum. — Chenu, 1859:233, fig. 1354.

Heliacus variegatus. — Finlay, 1927:401; Kira, 1954:12, pl. 12, fig. 4.

Heliacus variegatus depressiusculus Bayer, 1948:22.

Torinista variegata. — Rippingale and McMichael, 1961:63, pl. 6, fig. 27.

DESCRIPTION: *Protoconch* regularly coiled, varying .82-1.00 mm diam. *Teleoconch* elevated or depressed, 4½ flatly convex whorls, base convex. *Sutures* impressed, at top of narrow canal. *Sculpture* of 4 flatly rounded cords, cut into segments by numerous sharp oblique axial grooves; lowest cord forms a broad rounded peripheral keel, a further narrower basal keel below, followed by 4 flatter cords on base; basal cords are cut by numerous axial grooves which are weaker than those on dorsum. *Umbilicus* small and deep but perspective, averaging 25% of shell diameter at maturity, variable in width, umbilical cord irregularly cut into crowded segments; a strongly folded rough cord bisects the umbilical canal, dividing it into two deep channels. *Aperture* almost circular, outer lip strongly crenulated by cords; two narrow grooves at centre and base of inner-lip, extend a short distance into aperture. *Colour* — cords mottled with brown and white, axial markings most noticeable on peripheral and basal cord; green or brown periostracum. *Operculum* composed of many concentric layers of tough white chitinous material, inter-leaved with layers of extremely thin and fragile horn- coloured material of greater diameter, the whole built into a high rounded cone; usual peg-like projection at rear.

TYPE LOCALITY. "Australian Seas" (Lamarck).

DIMENSION: Holotype, none given. Average adult size, max diam 13 mm, alt 7 mm, 4½ whorls.

LOCATION OF TYPE: Unknown, unable to trace.

DISTRIBUTION: West coast, Rottnest Island, W. Australia (32° 00′ S., 115° 30′ E), northwards to Cape Dupuy — Cape Malouet, Barrow Island (20° 40-42′ S., 115° 26′ E). East coast, Murray Island, Torres Strait (9° 55′ S., 144° 05′ E), southwards along Queensland and New South Wales coasts to Woolgoolga, New South Wales (30° 07′ S., 153° 12′ E), also N.E. Herald Cay, Coral sea (21° 38′ S., 153° 46′ E). Inter-tidal and sub-tidal. Specimens also held at A.M. from Lord Howe Island, Indonesia and southern Philipinne Islands.

MATERIAL: Rottnest Island as above, 1 specimen Radar Reef coll S. M. Slack-Smith 16/12/64, W.A.M. No. N. 5228 (two further specimens, same locality, No. N. 5230 and 1 specimen No. N. 5229). 2 specimens Green Island platform, Rottnest Island coll E. P. Hodgkin 13/1/68, W.A.M. No. 96-73. Cape Dupuy — Cape Malouet area as above, 1 specimen coll W.A.M. — U.S.N.M. Barrow Island Exp 13/9/66, W.A.M. No., 728-67 (pt). Murray Is. as above, 1 specimen ex J. Kerslake coll, A.M. No. C. 92037. Woolgoolga as above, 2 specimens ex C. F. Laseron coll, A. M. No. C. 92038. N.E. Herald Cay as above, 1 specimen coll Yaldwin and McMichael Nov. 1964, A.M. No. C. 69064. A.M. 209 specimens (43 lots). N.M.V. 87 specimens (13 lots), W.A.M. 43 specimens (23 lots), S.A.M. 26 specimens (8 lots), Q.M. 8 specimens (4 lots), total 373 specimens (91 lots).

DISCUSSION: Gmelin (1791:3575) described and named the within species as *Trochus variegatus,* and referred to figs 1708 and 1709 in *Conch. Cab.* 5:184, pl. 173. The next species described on the same page was *Trochus areola* and referred to the next two figures Nos. 1710 and 1711. These two sets of figures certainly show a decided difference, but unfortunately this appears to be a further instance of European workers in the past relying on only two or three specimens for unnecessary separation into new species. In the process far too much emphasis has been placed on very minor differences in colour pattern and other variable features, whilst drawings and paintings have been copied in later works and lost definition in the process. A study in the field of large colonies of living *Heliacus variegatus* in Queensland and northern New South Wales will show quantities of specimens conforming to both the above lots of illustrations, with every possible intergrade in colour pattern. In addition the depth of colour varies from light reddish-brown to blackish-brown within the same colony, the width of umbilicus is not constant, sculpture may vary from coarse to fine nodules in many shapes, and the height/width ratio may vary from 58% to as much as 84%.

Heliacus areola (Gmelin) and the subsp. *H. depressiuscula* Bayer, 1948, are both synonyms, together with several other varietal names. Many specimens commence with the sub-sutural cord pure white as shown in *Conch. Cab.* figures 1710 and 1711, but in many cases this later becomes spotted or maculated with colour on the body-whorl or earlier.

Some specimens of this species can be confused with *Heliacus (Torinista) dorsuosus* (Hinds), especially any specimens which are more depressed than usual, but can be separated at maturity by the rounded peripheral area compared with the two distinct peripheral and basal keels in the latter species, also by the coarser sculpture, narrower umbilicus, and oblique striped form of coloration, compared with the confused colour pattern of *H. (T). dorsuosus,* with the alternate white and red-brown groups of nodules on peripheral keel. Discarding of all beach-worn specimens renders separation considerably easier.

I have been advised personally by Mr. George Buick, Librarian, Murdoch University, Western Australia, that he has observed at low tide hundreds of specimens of this species near Ela Beach, Port Moresby, P.N.G., on masses of small blue-green polyps attached to dead staghorn coral. The specimens were in groups of twos and threes, some juvenile and some mature. Many specimens dislodged from the coral were suspended above the water by fine threads up to 75 mm in length, the threads being of such strength that some specimens revolving rapidly in the wind were not dislodged.

Subgenus *Torinista* Iredale, 1936:327. Type species by original designation *Torinista popula* Iredale, 1936 (=*Solarium dorsuosum* Hinds, 1844).

REFERENCES: Wenz, 1938-44:668.

DIAGNOSIS: Small to medium, 3-20 mm diam; moderately to flatly depressed, spirally corded dorsally and basally; umbilicus narrow to wide; a peripheral keel with a definite basal keel below, the interspace between keels being either wide or narrow and recessed; operculum medium to high conical, of many layers. One species only, *Heliacus (Torinista) corallinus* nov., has an anal keel on protoconch.

Heliacus (Torinista) dorsuosus (Hinds, 1844). Fig. 2 (13-15), 9 (1-6).

Solarium dorsuosum Hinds, 1844a:23; 1844c:439; Philippi, 1853:37.

Solarium (Torinia) dorsuosum. Hanley (Sowerby), 1863:238, pl. 5, figs 73, 74.

Torinia dorsuosa. — Marshall (Tryon), 1887:17, pl. 5, figs 80, 81; Hedley, 1909:360; Schepman, 1911:221.

Torinista popula Iredale, 1936:327, pl. 24, fig. 15.

DESCRIPTION: *Protoconch* regularly coiled, varying .67-.97 mm diam. *Teleoconch* moderatly or flatly depressed, 3½ flatly convex whorls, base roundly convex. *Sutures* finely incised, joined between peripheral and basal keels. *Sculpture* of 4 flat-topped segmented spiral cords, occasionally 3 only, numerous deep narrow oblique axial channels intersected by 2 or 3 sharp incised spiral lines; a larger gemmate peripheral keel is separated from adjoining cord by a row of deep pits, gemmules axially straight; a smaller gemmate basal keel is separated from peripheral keel by a narrow axially striated channel, occasionally a fine spiral thread present; following this are 5 segmented cords on base, of various widths,separated by interstices of small deep pits, the last cord adjoining a crenulated periumbilical cord; all above segments rise to a low oblique axial ridge in centre of each. *Umbilicus* wide and perspective, 27-35% of shell diameter at maturity; umbilical cord with strong axially ridged and pointed crenulations; umbilical canal flat based and divided by a fine central gemmate cord. *Aperture* circular, with narrow groove in centre of inner-lip. *Colour* off-white, fawn or light brown, with fine darker brown spots at intervals on peripheral and basal keels. *Operculum* consists of layers of fawn chitinous material, built up to cone shape with concave top, the usual peg-like projection at rear, and is typical of the genus.

TYPE LOCALITY: Puerto Galero, Mindoro, Philippine Islands, 13 metres.

DIMENSIONS: Holotype, max diam 13.7 mm, alt 8.5 mm, 3½ whorls, fully grown.

LOCATION OF TYPE: Holotype should be with B.M.N.H. but catalogue reveals that it was never received, therefore presumed lost.

DISTRIBUTION: West coast, 3 km W. of Legendre Island, Dampier Archipelago (20° 23′ S., 116° 55′ E.), 41 metres, southwards along W. Australian coast to Rottnest Island (32° S., 115° 30′ E.), east coast, Bateman's Bay, New Sousth Wales (35° 43′ S., 150° 11′ E.), 137-155 metres, greatest depth recorded; northwards along New South Wales and Queensland coast to North-West island, Capricorn Group (23° 28′ S., 152° E.) Intertidal to 155 metres. Extends from Australian localities shown northwards through Indonesia to type locality in Philippine Islands.

MATERIAL: Legendre Island as above, 2 specimens coll B. R. Wilson 9/6/60, W.A.M. no. 103-73. Rottnest Island as above, 1 specimen coll 18/3/69, W.A.M. no. 130-73; 1 live specimen also between Cape Dupuy and Cape Malouet, Barrow Island, Western Australia (20° 40′ S., 115° 25′ E.), W.A.M. — U.S.N.M. Exped, 13/10/66, Stn. 6, W.A.M. No.

206-73; Bateman's Bay as above, 1 specimen coll C. F. Laseron, A.M. No. C. 94385. North-West island as above, 1 specimen coll T. Iredale and G. P. Whitley May 1929, A.M. No. C 94386. Total specimens examined form all Australian Museums 170 (83 lots).

DISCUSSION: This species appears to have been confused for many years in Australia with the new subsp. *Heliacus (Heliacus) cerdaleus ponderi* Garrard, described in this revision, which occurs partly over the same areas on both east and west coasts. Apart from several minor differences, the two species can be separated readily by the double keels on the periphery of *H. (Torinista) dorsuosus*, with the very narrow axially striated channel between; this compares with the rounded or flatly rounded peripheral area in *H. (H). cerdaleus ponderi*, which has four cords, the two outermost being a little stronger than the two central cords.

Differences between *H. (T). dorsuosus* and *H. (H). variegatus* (Gmelin) are described under "Discussion" following description of the latter species.

Heliacus (Torinista) concavus (Thiele, 1918). Fig. 4 (16-18).

Torinia concava Thiele, 1918:81 (115, pl. 9 (21), figs 4, 5; Bayer, 1948:10.

DESCRIPTION: *Protoconch* regularly coiled, varying .48-.83 mm diam. *Teleoconch* flatly depressed dorsally, approx 4 whorls in diam of 3.5 mm, sharply centrally ridged basally with flat inward-sloping edge. *Sutures* incised, at base of deep narrow canal. *Sculpture* dorsally of one strongly beaded cord on both margins, 3 strong beaded striae between, the whole crossed by numerous close-set oblique axial ribs, nodular at intersections; a beaded peripheral keel, a similar keel below, closely spaced and projecting slightly further than the upper keel; beneath this are 4 similar narrow beaded cords, the last forming the sharply raised edge of a ramp sloping down to umbilicus, and carrying 2 finely beaded spiral striae. *Umbilicus* widely perspective, averaging 34% of shell diam at maturity; umbilical cord with regular sharply pointed crenulations; umbilical canal wide, flat-based and crossed by numerous axial striae. *Aperture* sub-circular internally, square externally, sharp-edged and crenulate. *Colour* pale translucent fawn in live state, some opaque white, one brown spot on top of protoconch, further spot on edge of protoconch aperture; some specimens with few brown spots on peripheral keels. *Operculum* not available.

TYPE LOCALITY. Off North-east coast of Zanzibar (5° 55′ 8″ S., 39° 1′ 2″ E.), *"Valdivia" Stn. 244.*

DIMENSIONS. Holotype, max diam 3.5 mm, alt 1.4 mm. Largest specimen examined max diam 2.7 mm, alt .9 mm (2 whorls).

LOCATION OF TYPE: Humboldt University Museum, East Berlin, Reg'd No. ZMB. Moll. 101911.

*DISTRIBUTION: On west coast, W. of Bunbury, Western Australia (*33° 03′ S.,114° 44′ E.), 156 metres, northwards to 225 km N. of Cape Leveque (14° 29′ S., 123° 03′ E.), 124 metres; along northern coastline and southwards along Queensland coast to Palm Islands, (18° 45′ S., 146° 46′ E.), 27 metres, to Sugarloaf Point, New South Wales (32° 18′ S., 152° 50′ E.), 113 metres. Also off Gillett Cay, Swain Reefs, Queensland (21° 43′ S., 152° 25′ E.) Greatest depth recorded 194 metres, 161 km N.W. of Roebuck Bay, Western Australia (16° 58′ S., 120° 47′ E.) Widespread throughout Indian Ocean to western Pacific, northwards to P.N.G. (A.M. 2 specimens, Amazon Bay, P.N.G., 13 metres).

MATERIAL: W. of Bunbury as above, 1 specimen coll CSIRO, H.M.A.S. *"Gascoyne"* 10/8/62, A.M. No. C. 94486; N. of Cape Leveque as above, 3 specimens coll P. H. Colman 12/11/67, M.V. *"Kos 2"* (B.M.R. Stn. K 67-181), A.M. No. C. 94471. Palm Islands as above, 5 specimens coll C. Hedley, A.M. No. C.10268; Sugarloaf Point as above, 1 specimen Dec. 1967, H.M.A.S. *"Warrego,"* A.M. No. C. 94472; off Gillett Cay as above, 2 specimens, 63-73 metres, coll A.M. Party 17-19 Oct. 1962, A.M. No. C. 94473. Total A.M. 21 specimens (12 lots).

DISCUSSION: The V-shaped base of this species is similar in general formation to that of *H. (Claraxis) foveolatus* (Tate), but the latter species has only one peripheral keel and no basal keel.

Heliacus (Torinista) corallinus sp. nov. Fig. 6 (18-20)

DESCRIPTION: *Protoconch* brown, inflated, 3 whorls, smooth and shining, peritreme entire and forming a greatly reflected broad varix, short anal keel present. *Teleoconch* 3 whorls, flatly convex dorsally and basally, bi-angulated at periphery. *Sutures* strongly impressed at base of deep narrow canal. *Sculpture* of 4 flatly crenulated cords, separated from gemmate peripheral keel by a narrow channel; a similar gemmate basal keel below the peripheral, of equal strength, one narrow gemmate cord in concave space between, crossing numerous fine axial striae; 5-6 crenulated cords on base between basal keel and gemmate umbilical cord. *Umbilicus* wide and perspective, averaging 44% of shell diam at maturity, width variable; umbilical canal with slightly convex base, strongly axially striated, microscopic spiral threads. *Aperture* circular, grooved behind keels and at base of inner-lip, which is not reflected; outer-lip crenulated exteriorly by cords. *Colour* — protoconch brown, adult whorls maculated light brown and white, 2 or 3 brown and white gemmules alternately on both keels. *Operculum* not available.

TYPE LOCALITY: Michaelmas Cay, north Queensland (16° 36′ S., 145° 59′ E).

DIMENSIONS: Holotype max diam 5.7 mm, min diam 4.8 mm, alt 2.8 mm, 3 whorls. Fully grown.

LOCATION OF TYPE: A.M., Sydney, Reg'd No. C. 94340.

DISTRIBUTION: Michaelmas Cay as above; Burleigh Heads, south Queensland (28° 06′ S., 153° 27′ E.); Euston Reef, outer Barrier Reef, off Cairns, Queensland (16° 41′ S., 146° 15′ E.); Lord Howe Island (31° 33′ S., 159° 05′ E).

MATERIAL: Michaelmas Cay as above, holotype and 6 paratypes, G.B.R. Boring Exped, May-June 1926, coll T. Iredale and G. P. Whitley, A.M. No. C. 94340; Burleigh Heads as above, 2 specimens. Q.M. Reg'd No. M.O. 5715; Euston Reef as above, 5 specimens, 21 metres, coll P. H. Colman 30/11/72, A.M. Reg'd No. C. 105042; Lord Howe Island as above, 2 specimens coll Roy Bell, A.M. No. C 59593 (pt). Total specimens 16 (4 lots). Appears to be endemic to eastern Australian area.

DISCUSSION: This species resembles *H. (Torinista) costatus* (Schepman), *H. (T). fulvus* (Hinds) and *H. (T). dorsuosus* (Hinds) but may be separated by the following differences. From *H. (T). costatus,* the fine spirals in interstices between axial riblets are replaced by strong spiral grooves in this new species, also the broad ribbed space between basal keel and first spiral on base is replaced in this new species by a much narrower groove. The 5 spiral dorsal cords in *H. (T). fulvus* are replaced by only 4 in this

new species, also the suture is joined at top of basal keel in this new species in lieu of base of top peripheral keel in *H. (T). fulvus*. From *H. (T). dorsuosus* this new species differs in having a deep narrow canal at the sutures, in addition to which the periumbilical cord is finely gemmate and not sharply crenulate. However, the feature which sets this new species apart from all others is the possession of an anal keel on the protoconch. The varix at the protoconch aperture is reflected to a much greater extent than usual, being turned backwards and flattened, forming a broad heavy band of callus. A short sharp anal keel behind the band leaves a narrow and very deep crescent shaped pit between the keel and varix. Only about ¾ of the final whorl of the inflated protoconch is visible dorsally.

The 5 specimens mentioned under "Material" from 21 metres off Euston Reef, Queensland, were taken from the foot of a sandy slope beneath steep coral walls, indicating almost certainly that when alive the species exists in crevices in the vertical coral.

Heliacus (Torinista) costatus (Schepman, 1899) Fig. 5 (7-9).

Torinia costata Schepman, 1899:221, pl. 14, fig. 5.

DESCRIPTION: *Protoconch* regularly coiled but slightly inflated, varying .68-.83 mm diam. *Teleoconch* flatly depressed, 3¼ flatly convex whorls, deeply canaliculate, base convex. *Sutures* strongly impressed at base of deep narrow canal. *Sculpture* of strong oblique axial ribs on all whorls, with beaded spiral cords on both inner and outer margins, the outer forming a strong peripheral keel; a further beaded basal keel of same strength as that above, space between being concave, vertical striations joining nodules, one central microscopic thread often present; base with strong axial ribs divided by narrow channels, with one finely beaded cord towards outer margin, and 3 or 4 broader crenulated cords between beaded cord and umbilicus. *Umbilicus* widely perspective, averaging 39% of shell diameter at maturity; umbilical cord strong with sharply pointed crenulations; umbilical canal flat-based, obliquely striated, with low ridge towards apical edge. *Aperture* sub-circular, strongly crenulated by external cords, two grooves behind peripheral keels, inner-lip arcuate. *Colour* off-white, marked with light fawn on groups of 2 or 3 peripheral nodules alternately with white, brown spots on protoconch. *Operculum* not available.

TYPE LOCALITY: Rumah-Kuda bay, Roma (Romang) Island, 36 metres. (7° 36′ S., 127° 25′ E.), north of eastern tip of Timor.

DIMENSIONS: Holotype, max diam 9 mm, alt 3.5 mm. Fully grown.

LOCATION OF TYPE: Amsterdam Museum, Netherlands, reg'd number not ascertained.

DISTRIBUTION: Arafura Sea, 160 km N. of Croker Island, Northern Territory (9° 30′ S., 132° 34′ E.), Van Diemen's Inlet, Gulf of Carpentaria (16° 59′ S., 140° 59′ E.), Buchan's Point, north of Cairns, Queensland (16° 44′ S., 145° 40′ E.), southwards along Queensland and New South Wales coasts to Manly Beach, Sydney, New South Wales. Northwards from Australia at least as far as the type locality north of Timor.

MATERIAL: Arafura Sea as above, 2 specimens, 124 metres, coll P. H. Colman 9/11/69, M.V. *"San Pedro Sound,"* (B.M.R. Stn. P69-1144), A.M. No. C. 92040; Van Diemen's Inlet as above, 1 specimen coll C Hedley, A.M. No. C.15375; Buchan's Point as above, 1 specimen coll J. Kerslake July 1964, A.M.No. C. 92041; Manly Beach as above, 1 specimen ex C. F. Laseron coll, A.M. No. C. 92039. A.M. 12 specimens (6 lots).

DISCUSSION: The nearest congeners to this species appear to be *H. (Torinista) dorsuosus* (Hinds) and *H. (T). mazatlanicus* (Pilsbry and Lowe), both easily separated by the possession of strong spiral cords dorsally in lieu of the numerous axial riblets on *H. (T). costatus*. A further congener is *H. (T). caelatus* (Hinds), a species growing to 9 mm diam and very similar in appearance, but having decidedly coarser sculpture, with only 50 ribs on body-whorl compared with 90 ribs on *H. (T). costatus*. Despite the type locality for *H. (T). caelatus* being the Straits of Macassar and being widely distributed throughout the Western Pacific (Keen, 1971:389), there does not appear to be any record of its occurrence in Australia. Hedley (1909:360) included *H. (T). caelatus* in his check-list of Queensland species, but the specimens which he collected in that State prove to be *H. (T). costatus* (Schepman).

The 12 specimens held by A.M. agree precisely in every particular with Schepman's figure and description with the sole exception of the fine spiral striae between the dorsal rib, which is completely lacking. However, all are dead specimens and any microscopic raised striae could easily be eroded, alternatively this could be a variable feature peculiar to more tropical specimens.

Heliacus (Torinista) delectabilis (Melvill, 1893) Fig. 5 (1-3).

Solarium (Torinia) delectabile Melvill, 1893:57, pl. 1, fig. 11.

Torinia delectabilis. — Bayer, 1948:14.

DESCRIPTION: *Protoconch* smooth and shining, inflated and prominent, raised above first adult whorl, varying 1.00-1.16 mm diam. *Teleoconch* flatly depressed, 3 flat-topped whorls in diam of 6 mm, flatly rounded dorsally, convex base, periphery flat, strongly beaded. *Sutures* deeply incised at base of narrow canal. *Sculpture* dorsally consists of a strong beaded cord on either margin, 3 narrower beaded cords between, crossed by strong oblique axial grooves; outer cord forms peripheral keel, with a further similar but narrower nodular basal keel below; interspace between keels is flat, barely recessed, with one or two fine nodular threads; on base are two fine, two medium and one broad decussated cord, surrounding crenulated umbilical cord. *Umbilicus* small and barely perspective, averaging 22% of shell diam at maturity; umbilical cord with small regular crenulations; umbilical canal flat based, axially and spirally finely striated. *Aperture* sub-circular, inner-lip arcuate with short groove at base; outer-lip crenulated exteriorly by keels. *Colour* off-white or cream, pale chestnut spots widely spaced on peripheral keel, brown spot on top of protoconch and at edge of protoconch aperture. *Operculum* not available.

TYPE LOCALITY: Bombay.

DIMENSIONS: Holotype, max diam 3 mm, alt 2.5 mm. Largest specimen examined, max diam 6 mm, alt 3.3 mm, 3 whorls (Specimen figured, A.M. No. C. 92021.

LOCATION OF TYPE: B.M.N.H. Reg'd No. 1893.2.16.38.

DISTRIBUTION: Off Dongara, Western Australia (29° 15′ S., 114° 01′ E.), to Rocky Point, southern coast of Western Australia (34° 13′ S., 125° 04′ E.); 123-125 metres; off Beachport, South Australia, 150 metres (37° 30′ S., 140° E.); eastwards to Twofold Bay, New South Wales (37° 06′ S., 149° 55′ E.), 90 metres. northwards to Crowdy Head, Manning River mouth, New South Wales (31° 50′ S., 152° 45′ E.), northwards to Moreton Bay, southern Queensland (27° 02′ S., 153° 28′ E.), 114-124 metres. Eastern Indian Ocean to east coast of Australia.

MATERIAL: Dongara as above, 1 specimen H.M.A.S. *"Diamantina"* 20/3/72 (DM 1/72), Stn. 55, W.A.M. No. 205/73. Rocky Point as above, 1 specimen 160 km S.E., H.M.A.S.

"Gascoyne," (G2/105/62), A.M. No. C.92019. Beachport as above, 1 specimen S.A.M. not reg'd. Twofold Bay as above, 1 specimen T.A. Garrard coll, A.M. No. C. 92020. Moreton Bay as above, 1 specimen ex T. A. Garrard coll, A.M. No. C. 71469. Total specimens examined from all Australian Museums 24 (18 lots).

DISCUSSION: This species is close to *H. (Torinista) fulvus* (Hinds), but in lieu of the overall blotched and maculated colour of that species it has widely spaced fawn spots on peripheral keel and 2 spots on protoconch in all specimens examined. All specimens also have only 5 cords on dorsum, with interstices bearing strong radial striae, in lieu of the 6 cords on each whorl in *H. (T). fulvus*. The spire of *H. (T). delectabilis* is a little higher and the sutures deeper and better defined than in *H. (T). fulvus*. The two syntypes of *H. (T). fulvus* have been compared with the holotype of *H. (T). delectabilis* at B.M.N.H., the above differences quoted, and it is stated that they are definitely not considered to be conspecific.

The very fine sculpture between nodules on the spiral cords described by the author requires at least 30X magnification to be seen clearly, and consists of extremely fine growth lines and granulations, which glitter under the light.

Heliacus (Torinista) fenestratus (Hinds, 1844) Fig. 4 (19-21).

Solarium fenestratum Hinds, 1844a:25; 1844b:52, pl. 14, figs 21, 22; 1844c:440. Philippi 1853:23, pl, 3, fig. 13.

Torinia fenestrata. – Marshall (Tryon), 1887:20, pl. 6, figs 100, 1.

Solarium (Torinia) fenestratum. — Hanley (Sowerby), 1863:241, pl, 5, figs 77, 78 (error for 79, 80).

DESCRIPTION: *Protoconch* regularly coiled, a little inflated, smooth and shining, varying 1.17-1.77 mm diam. *Teleoconch* flatly depressed, 3½ whorls in diam of 7.5 mm, whorls flatly rounded, strongly beaded, base widely umbilicate. *Sutures* incised, at base of wide deep canal. *Sculpture* of 3 strongly beaded cords on first 1½ whorls, 4 on penultimate and body-whorl, with a fifth similar cord forming a strong keel; below this is a further similar basal keel, the two bi-angulating the whorls with a fine thread between; below basal keel are 4 further beaded cords and one or two threads; a similar beaded umbilical cord is separated from others by a narrow canal; entire surface carries strong raised oblique threads crossing all cords and interstices, dividing cords into nodules. *Umbilicus* very wide and perspective, averaging 50% of shell diameter at maturity with deep, narrow canal, which has one or two finely crenulated cords on its base. *Aperture* circular interiorly, crenulated exteriorly by cords, fine grooves internally below cords, peritreme entire or almost so at maturity. *Colour* pale fawn with narrow light brown axial lines crossing periphery and extending partly over dorsum and base. *Operculum* roundly conical with hollow centre, comprised of solid gelatinous material with about 10 layers of very thin ragged-edged chitinous material in form of circular "fins," off-white in colour.

TYPE LOCALITY: New Guinea.

DIMENSIONS: Holotype, max diam 7.4 mm, alt 3.5 mm, 3½ whorls, approx max size.

LOCATION OF TYPE: Should be held by B.M.N.H. but cannot be traced.

DISTRIBUTION: On west coast, south passage Shark Bay, Western Australia (25° 30′ S., 113° 30′ E.); east coast, Michaelmas Cay off Cairns, Queensland (16° 45′ S., 146° 05′ E.), and G.B. Reef off Cairns (16° 55′ S., 146° 19′ E.). Inter-tidal and sub-tidal. Central Indo-Pacific generally extending northwards to Philippine Islands and Japan.

MATERIAL: Shark Bay as above, 1 specimen (live) under coral, coll R. Butler 7/5/66, W.A.M. No. 170-66; Michaelmas Cay as above, 2 specimens coll T. Iredale and G. P. Whitley May-June 1926, G.B.R. Boring Exp, A.M. No. C. 53488 (pt); G.B.R. off Cairns as above, 1 specimen coll D. Pitt, A.M. No. C. 46060. 2 specimens also held by A.M. coll C. Hedley, from Bird Island, Coral Sea (22° 13′ S., 155° 40′ E.) Total specimens examined A.M. and W.A.M., 10 (5 lots).

DISCUSSION: Compared with its closest congener, *Heliacus (Torinista) infundibuliformis* (Gmelin), the within species grows to only half the size with a corresponding number of whorls, the oblique axial beads on all cords on dorsum are twice as numerous, and the whorls are more rounded on base, which is less sharply ridged in centre than *H. (T). infundibuliformis*. Differences in colour are also shown in description.

Heliacus (Torinista) fulvus (Hinds, 1844). Fig. 8 (10-15).

Solarium fulvum Hinds, 1844a:24; 1844b:51, pl. 14, figs 17, 18; 1844c:439; Philippi, 1853:21, pl. 3, fig. 11.

Solarium (Torinia) stramineum var. *fulva* Hanley (Sowerby), 1863:242; Bayer, 1948:35.

TYPE LOCALITY: New Guinea.

DIMENSIONS: Holotype, max diam 7.4 mm, alt 3.2 mm.

LOCATION OF TYPE: B.M.N.H., Reg'd Nos. of 2 syntypes 1844:6:7:34 and 1879:2:26:158.

DISCUSSION: This species is apparently not recorded from Australia, but photographs of the 2 syntypes having been supplied by B.M.N.H. they are shown at fig. 8 (10-15) to assist with recognition. A letter from B.M.N.H. states "The Hinds collection was donated to this Museum in 1842 but Belcher received some of the material, which he donated in 1844 to this Museum. The rest of the Hinds material went to the Lombe Taylor collection... In 1879 the rest of the Lombe Taylor collection was purchased through G. B. Sowerby by this Museum. At this time *Solarium fulvum* (79:2:26:158).....and others.....were acquired." As the two specimens now illustrated were acquired by B.M.N.H. as above from the Hinds collection, it is possible that they represent part of a syntypic series, although the measurements of neither agree with those shown by the author for the holotype.

The colour as shown in the original description is merely "fulva" meaning probably tawny or light brown. The dorsal view of No. 1844:6:7:34 shown at Fig. 8 (1) shows the specimen apparently maculated with this colour and off-white in irregular blotches.

Heliacus (Torinista) cf. implexus (Mighels, 1845). Fig. 9 (16-18).

Solarium implexum Mighels, 1845:22. — Hanley (Sowerby), 1863:244.

Torinia implexa. — Marshall (Tryon), 1887:23. — Bayer, 1948:37.

DESCRIPTION: *Protoconch* regularly coiled, varying 1.03-1.27 mm diam. *Teleoconch* depressed, 2½-3 whorls, flat dorsally, flatly convex on base, whorls bi-angulated. *Sutures* finely incised, joined between peripheral and basal keels. *Sculpture* of 4 flatly-raised spiral cords bounded by a wider and stronger peripheral keel, the whole decussated by strong flatly-rounded oblique axial striae; microscopic spiral threads visible on all cords, especially peripheral keel; base with 5 similar spiral cords, bounded by basal keel, a little more contracted than peripheral keel above; space between keels deep and narrow with

close-set vertical striae. *Umbilicus* widely perspective, averaging 40% of shell diam at maturity; umbilical cord with regularly spaced and pointed crenulations; umbilical canal wide and shallow, concave base, with close-set vertical striae. *Aperture* sub-circular with deep and narrow grooves behind peripheral keels and at base of inner-lip, which is strongly recurved; outer-lip a little thickened and crenulated by keels. *Colour* translucent white, irregular pale fawn markings on both dorsal and basal spiral cords, occasional pale spot s of samecolour on peripheral keels. *Operculum* not available.

TYPE LOCALITY: Oahu, Hawaii (author).

In referring to the type locality Johnson (1949:217) quotes a note by W. H. Pease stating "The marine species were from Kauai without doubt." This is the western-most of the main Hawaiian Islands, co-ordinates approx 22° N., 159° 30′ W.

DIMENSIONS: Holotype, max diam 6.76 mm. Largest specimen examined, max diam 8 mm, alt 3.3 mm, 3 whorls (N. of Barrow Is., Western Australia, as below).

LOCATION OF TYPE: Unknown, cannot be traced.

DISTRIBUTION: On west coast, N. of Barrow Is. (20° 46′ S., 114° 51′ E.), 104 metres; 193 km N. of Port Hedland (18° 40′ S., 119° 23′ E.), 117 metres; 290 km W. of Broome (18° 25′ S., 119° 50′ E.), 115 metres; 161 km N.W. of Broome (16° 58′ S., 120° 47′ E.), 194 metres; 225 km N. of Cape Leveque (14° 29′ S., 123° 03′ E.), 124 metres; eastwards to Murray Is., Torres Strait (9° 55′ S., 144° 05′ E.), 9-15 metres; Opal Reef, N. of Cairns, Queensland (16° 13′ S., 145° 54′ E.), 27 metres; N.E. of Yeppoon, 103 km (22° 50′ S., 151° 39′ E.), 64 metres; off Masthead Is. (23° 10′ S., 151 54′ E.), 31-37 metres; E. of Port Jackson, New South Wales, 75-150 metres. Shallow water to 194 metres, greatest depth, N.W. of Broome as above. Apparently widespread throughout Pacific and probably eastern Indian Ocean, but definite records are not available.

MATERIAL: N. of Barrow Is. as above, 1 specimen coll P. H. Colman 10/10/68, M.V. ""*Espirito Santo,*" B.M.R. Stn. E68-681, A.M. No. C. 98315; N. of Port Hedland as above, 1 specimen coll P. H. Colman 6/10/68, M.V. "*Espirito Santo,*"B.M.R. Stn. E68-549, A.M. No.C. 98314; W. of Broome as above, 4 specimens coll P. H. Colman 6/10/68, M.V. "*Espirito Santo,*" B.M.R. Stn. E68-547, A.M. No. C. 98313; N.W. of Broome as above, 2 specimens coll P. H. Colman 29/11/67, M.V. "*Kos 2*", B.M.R. Stn. K67-248, A.M. No. C. 98312; N. of Cape Leveque as above, 1 specimen coll P.H. Colman 12/11/67, M.V. "*Kos 2*", B.M.R. Stn. K67-181, A.M. No. C. 98311; off Murray Is. as above, 1 specimen coll C. Hedley, A.M. No. C. 98319; Opal Reef as above, 1 specimen coll P. H. Colman 25/11/72, A.M. No. C. 98316; N. E. of Yeppoon as above, 1 specimen coll P. H. Colman 25/9/70, M.V. "*San Pedro Strait,*" B.M.R. Stn. 1261, A.M. No. C. 98317; off Masthead Is. as above, 2 specimens coll C. Hedley, A.M. No. C. 19629; E. of Port Jackson as above, 1 specimen coll CSIRO 18/7/62, H.M.A.S. "*Gascoyne,*" Stn. G2/55-57/62, A.M. No. C. 98318. A.M.15 specimens (10 lots), also 1 specimen Nadi Bay, Viti Levu, Fiji, A.M. No. C. 69063, and 12 specimens Lord Howe Is. coll Roy Bell, A.M. No. C.59593.

W.A.M. 1 specimen coll T. Richert, June-July 1967, 36-73 metres off Waikiki, Oahu, Hawaii, W.A.M. No. 90-73.

DISCUSSION: This species has veen regarded by authors in the past as a *nomen dubium* owing to the concise description and lack of an illustration; however the original description coincides in all details with the description now given, and in view of the above W.A.M. specimen being found very close to the type locality it is probable that identification as *H. (Torinista) implexus* (Mighels) is correct.

Heliacus (Torinista) infundibuliformis (Gmelin, 1791). Fig. 7 (19-21).

Turbo crenellus Linnaeus, 1767:1236; Gmelin, 1791:3602.

Trochus infundibuliformis Gmelin, 1791:3575; Angas, 1877:184.

Torinia infundibuliformis. — Adams, 1858:242, pl. 25, fig. 7.

Solarium chemnitzi Kiener, 1839:12, pl. 4, fig. 8.

Solarium infundibuliforme. — Philippi, 1853:11, pl. 2, figs 8, 9.

Solarium (Torinia)) infundibuliforme. — Hanley (Sowerby), 1863:243, pl. 5, figs 91-93.

Torinia infundibuliforme. — Marshall (Tryon), 1887:19, pl. 8, figs 97, 98.

Heliacus infundibuliformis. — Keen, 1971:391.

DESCRIPTION: *Protoconch* deep brown, smooth and shining, regularly coiled, varying .80-.98 mm diam. *Teleoconch* flatly rounded, 4 whorls in width of 15 mm, in form of tightly coiled tube. *Sutures* strongly incised at base of canal. *Sculpture* of 4 strong beaded cords with numerous smaller cords and fine threads between, all crossed by microscopic growth lines; base sculptured in similar manner; edge of whorls has concave section between two strong peripheral cords, with several fine threads and striations; a wide deep canal between whorls with incised suture at base. *Umbilicus* very wide and perspective, averaging 68% of shell diameter at maturity, bordered by strong crenulated cord, beaded in its earlier stages, inside which are smaller beaded cords, with still finer threads and striations between; umbilical canal broad and shallow, flat-based, 3-6 fine spiral striae crossed by microscopic growth lines. *Aperture* circular interiorly, strongly crenulated exteriorly by the numerous cords, two peripheral and one basal cord being prominent; inner-lip reflected. *Colour* medium to dark brown, occasionally with regularly spaced white axial streaks partly across top of whorls and round periphery to base; fawn periostracum. *Operculum* consists of about 12 layers of fawn chitinous material, expanding in size from apex to base, ragged in appearance and roughly formed; not built up to usual rounded cone shape, but flatter with generally untidy appearance.

TYPE LOCALITY: None given.

DIMENSIONS: Holotype, none given. Largest specimen examined max diam 20 mm, min diam 16 mm, alt 7.5 mm, 4½ whorls.

LOCATION OF TYPE: Uknown, unable to trace.

DISTRIBUTION: West coast, between Cape Dupuy and Cape Malouet, Western Australia (20° 40-42′ S., 115° 25′ E.), only known W. Aust. record; eastwards to Murray Is., Torres Strait (9° 55′ S., 144° 05′ E.), N.E. Herald Cay, Coral Sea (21° 38′ S., 153° 46′ E.); West Cay, Diamond Islets, Queensland (17° 25′ S., 150° 58′ E.), southwards along Queensland coast to Caloundra Beach (26° 48′ S., 153° 08′ E.) A widespread Indo-Pacific species, extending northwards to Japan.

MATERIAL: Cape Dupuy-Cape Malouet as above, 1 specimen W.A.M. — U.S.N.M. Barrow Is. Exped 13/9/66, W.A.M. No. 727-67; Murray Is. as above, 1 specimen coll C. Hedley, A.M. No. C. 29399; N. E. Herald Cay as above, 2 specimens coll J. C. Yaldwin and D. F. McMichael Nov. 1964, A.M. No. C. 69064; Diamond Islets as above, 1 specimen coll J. C. Yaldwin and D. F. McMichael Oct. 1964, A.M. No. C. 69165; Caloundra Beach as above, 3 specimens ex T. A. Garrard coll, A.M. No. C. 92032. Total specimens examined from all Australian Museums 42 (17 lots).

DISCUSSION: This species has been incorrectly cited by authors for many years as *Heliacus crenellus* (Linnaeus, 1758), a *nomen dubium*. It can be readily separated from all but one other species by its coiled-tube appearance, and the umbilicus consisting of the whole base of shell inside the central sharp basal cord. Differences between this species and its nearest congener, *Heliacus (Torinista) fenestratus* (Hinds), are described under "Discussion" following description of that species.

Heliacus (Torinista) virgatus (Hinds, 1844). Fig. 8 (16-18).

Solarium virgatum Hinds, 1844a:25; 1844b:52, pl. 14, figs 18, 19; 1844c:440; Philippi, 1853:21, pl. 3, fig. 10; Hanley (Sowerby), 1863:240, pl. 5, figs 85, 86; Marshall (Tryon), 1887:20, pl. 6, figs 2, 3.

TYPE LOCALITY: New Guinea.

DIMENSIONS: Holotype, max diam 4.2 mm, alt 2.1 mm.

LOCATION OF TYPE: B.M.N.H. Reg'd No. of possible holotype 1874:12: 11:190.

DISCUSSION: This species is apparently not recorded from Australia, but as photographs of the possible holotype have been supplied by B.M.N.H. they are shown at Fig. 8 (16-18) to assist with recognition. This species was isolated from the Hinds material at B.M.N.H. as being closest to the original measurements of the holotype, max diam being about 4.7 mm and alt 2.1 mm.

The colour stated in the original description is "cingulo supremo et ultimo rufis, medianis albis," i.e. reddish on the two cords at either margin and white on the two between, which appears to agree with the dorsal view at Fig. 8 (16).

FOSSIL SPECIES

Heliacus (Torinista) darraghi sp. nov. Fig. 10 (4-6).

DESCRIPTION: *Protoconch* very small, 1½ smooth whorls, nucleus submerged, averaging .38-.43 mm diam. *Teleoconch* roundly depressed conic, 5 flat-topped whorls in diam of 13.8 mm, very convex basally. *Sutures* finely incised, joined below peripheral keel, forming slight canal. *Sculpture* of 6 strongly beaded spiral cords of varying strength, outermost forming peripheral keel; a pair of fine oblique threads links each nodule in one cord with corresponding nodule in adjoining cord; peripheral keel is stepped below adjoining cord by wide concave area; a beaded basal keel is more contracted than peripheral keel above, with one to 4 finer cingula and/or threads in space between; base with 5 beaded spiral cords and threads of varying strength, and a wide strongly axially crenulated area crossed by many microscopic spiral threads. *Umbilicus* medium and pesrspective, averaging 25% of shell diam at maturity; umbilical cord with widely spaced coarse crenulations, joined to surrounding wide crenulated area by numerous fine axial filaments crossing a wide and moderately deep sulcus with an occasional fine thread in centre. *Aperture* sub-circular, crenulated exteriorly by cords, grooved inside peripheral keel and at base of inner-lip, which is arcuate and reflected.

TYPE LOCALITY: Aw. 1. Point Flinders, Cape Otway, Victoria. Grid ref. Aire 367,097. Glen Aire Clay: Aldingan?: Upper Eocene.

DIMENSIONS: Holotype, max diam 13.8 mm, min diam 11.9 mm, alt 8.1 mm. One of the largest specimens studied.

LOCATION OF TYPE: N.M.V., Melbourne, Victoria, Fossil Dept., Reg'd No. P. 31321.

MATERIAL: Holotype and 14 paratypes, all type locality, coll F. A. Cudmore. 6 topotypes coll T. A. Darragh and T. Hughes 1/12/72, N.M.V. No. P. 31326. 3 topotypes coll T. A. Darragh and H. E. Wilkinson 5/12/68, N.M.V. No. P. 31323. 1 specimen uppermost bed, washout nearest Brown's Creek, Victoria, Grid ref. Aire 277, 177. Brown's Creek Clay: Aldingan: Upper Eocene, N.M.V. No. 31320 (pt). 1 topotype coll T. A. Darragh and H. E. Wilkinson 13/12/72, N.M.V. No. P. 34817. 1 specimen in cutting Boornong Road, 1.3 miles N. of Cooriemungle Road, Cooriemungle, Victoria, Grid ref. Princetown 982, 485, coll T. A. Darragh and T. Hughes 25/11/72, N.M.V. No. P. 34819. Total specimens N.M.V. 27.

DISCUSSION: The fine pairs of threads linking the nodules in each adjoining cord are a good recognition feature in this new species, and have not been observed in any other Victorian Tertiary fossil. The species is named for Thomas A. Darragh, Deputy Director, N.M.V., Melbourne, Victoria, in appreciation of his assistance to the author on many occasions with loan of material and checking of manuscripts.

Subgenus *AWARUA* Mestayer, 1930:144-6. Type species by original designation *Omalaxis amoena* Murdoch and Suter, 1905.

REFERENCES: Wenz, 1938-44:667; Bayer, 1948:5.

DIAGNOSIS: Original — "Shell very depressed, apex flat. Protoconch minute, smooth, the extreme tip hyaline, visible from below. Whorls keeled, very slightly descending, lightly rounded; sculpture spiral and radial." (Major diam 3 to 15 mm. No anal keel on protoconch).

NOTE: The author failed to describe the main distinguishing feature of this subgenus which sets it apart from all others viz., the wide concave area surrounding the umbilicus, with 3 rows of irregularly spaced and uneven nodules at top, centre and base, all crossed by numerous axial threads or filaments, crossing both nodules and interstices. (A simple explanation of this feature is that a great distension has occurred of the sulcus dividing the two periumbilical cords, or in this case the two rows of nodules).

Heliacus (Awarua) amoenus (Murdoch and Suter, 1905). Fig. 2 (16-18).

Omalaxis amoena Murdoch and Suter, 1905:293, pl. 24, figs 30, 32; Suter, 1913:318, pl. 15, fig. 21; Finlay, 1926:401.
Awarua amoena. — Mestayer, 1930:145; Powell, 1937:75.

Torinia amoena. Bayer, 1948:5.

DESCRIPTION: *Protoconch* regularly coiled, a little inflated, smooth and shining, varying .61-.76 mm diam. *Teleoconch* 2½ flat-topped whorls, dorsum and base flatly convex, sharp peripheral keel. *Sutures* joined at base of peripheral keel, finely incised and undulating. *Sculpture* of 3-4 fine threads and/or striae on each whorl in varied positions, bounded by a strong gemmate cord on either margin; a wide concave axially ribbed space below outer cord separates it from a finely axially ribbed peripheral keel on a lower plane; these fine riblets or threads cross 3 or 4 fine gemmate cords on the flatly or roundly sloping base, and deep into umbilicus. *Umbilicus* widely perspective, averaging 53% of shell diam at maturity, and bounded by a row of widely spaced strong pointed uneven nodules, not in form of a cord; two further finer periumbilical rows of nodules surround the inner row, also widely spaced; the 3 rows of nodules are widely spaced, central being in a shallow depression between inner and outer rows, and all are over-ridden in an irregular manner by the above numerous fine axial threads or riblets; umbilical canal flat-based and finely axially ribbed. *Aperture* sub-circular, inner- lip

strongly reflected and centrally grooved; outer-lip thin, crenulated exteriorly by cords, grooved behind peripheral keel. *Colour* opaque white. *Operculum* — Mestayer (1930:146) states regarding an operculum in a further specimen other than holotype: "....it is certainly of a conical type. under a 2/3 objective it apperars to be spirally wound, with the outer edges free. At the apex is a small pit, from which the first coil arises, passing spirally downwards." (This refers to the barely visible operculum well inside the body-whorl of the paratype.)

TYPE LOCALITY: Off Cuvier Island, east of Great Barrier Island, New Zealand (36° 08′ S., 175° 55′ E.), 219 metres.

DIMENSIONS: Holotype, max diam 3 mm, min diam 2.5 mm, alt 1 m, 2½ whorls. Largest specimen examined (A.M.No. C. 94341) max diam 4.1 mm, alt 1.9 mm. 2¾ whorls.

LOCATION OF TYPE: N.M.N.Z., Wellington, New Zealand, reg'd No. M 1680.

DISTRIBUTION: Apart from type locality, 3 other localities in the Arafura Sea, north of Northern Territory, as follows:
160 km N. of Croker Island, (9° 30 S., 132° 34′ E.). 125 metres.
150 km N.W. of Melville Island (9° 53′ S., 130° 02′ E.), 205 metres.
230 km N. of Goulburn Island (9° 18′ S., 133° 38′ E.), 135 metres.

MATERIAL: Holotype fowarded on loan from N.M.N.Z. 160 km N. of Croker Is. as above, 1 specimen coll P. H. Colman 9/11/69, M.V. *"San Pedro Sound"* B.M.R. Stn. P69-1144, A.M. Reg'd No. C. 94341. 150 km N.W. of Melville Is. as above, 1 specimen coll P.H. Colman 5/12/69, M.V. *"San Pedro Sound,"* B.M.R. Stn., P69-1220. A.M. No. C. 105119. (Immature, 1½ whorls). 2.2 x .8 mm. 230 km N. of Goulburn Is. as above, 1 specimen coll P. H. Colman, 1/11/69, M.V. *"San Pedro Sound,"* B.M.R. Stn., P69-1073, A.M. No. C. 105120. (Immature, 1¼ whorls). 1.9 x .7 mm.

DISCUSSION: A.M. specimen No. C. 94341 has been compared with the holotype, and 2 specimens examined later then compared with the first specimen. It was found that the fine gemmate cords on base between peripheral keel and outer periumbilical cord vary from 3 to 4; that the slope or ramp on which they are placed may vary from flat to slightly convex; the two fine striae and one thread in centre of each whorl dorsally may vary in position, also in one specimen they tend to disappear and then recur. The number of axial threads or riblets may vary on the dorsum of first whorl from 30 to 40, and on the body-whorl up to 60, due to bifurcation of the riblets in various places.

FOSSIL SPECIES

Heliacus (Awarua) otwayanus sp. nov. Fig. 10 (1-3).

DESCRIPTION: *Protoconch* smooth and shining, 1½ whorls, regularly coiled, averaging .96 mm diam. *Teleoconch* low conic, 5 flat-topped whorls in diam of 13.8 mm, base roundly convex. *Sutures* finely incised, joined at edge of peripheral keel. *Sculpture* dorsally of beaded cord on inner margin, a second cord close to periphery, 3 finer beaded striae between; space between outer cord and peripheral keel smooth and concave, usually a fine spiral thread present; peripheral keel finely beaded on first 3 whorls, smooth on body-whorl and penultimate; base of body-whorl with up to 15 scale-on-scale growth marks, others between are microscopic; one or two fine spiral threads on some specimens. *Umbilicus* wide and perspective, averaging 48% of shell diameter at maturity, with a wide concave area bordered on either margin by a row of sharply pointed crenulations, not in form of cords; scale-on-scale growth marks continued across umbilicus and obliquely across the deep and flat-based umbilical canal. *Aperture*

sub-rhomboid, grooved behind peripheral keel, at lower edge of inner-lip and at base of columella, which is vertical and slightly reflected.

TYPE LOCALITY: Aw. 1. Point Flinders, Cape Otway, Victoria. Grid ref. Aire 367, 097. Glen Aire Clay: Aldingan: upper Eocene.

DIMENSIONS: Holotype max diam 13.8 mm, min diam 12 mm, alt 7.1 mm, 5 whorls. Largest specimen.

LOCATION OF TYPE: N.M.V., Melbourne, Victoria, Fossil Dept., Reg'd no. P. 31325.

MATERIAL: Holotype and one paratype, also from type locality, coll T.A. Darragh and T. Hughes 1/12/72. 6 topotypes coll F. A. Cudmore, N.M.V. No. P. 31322. 2 topotypes coll T. A. Darragh and H. E. Wilkinson 5/12/68, N.M.V. No. P. 31324. Total N.M.V. 10 specimens.

DISCUSSION: The general formation of this species, especially the umbilical area peculiar to the type for the genus places it without doubt as being congeneric, despite the differences in basal sculpture. The further new *Awarua* species described in this revision but not named because of lack of material, serves as a link between *H. (A). otwayanus* and *H. (A). amoenus*, type for the genus, by its intermediate type of basal sculpture.

A Recent unidentified specimen was collected by C. Hedley from 183 metres off Port Macquarie, New South Wales, A.M. No. C. 37723; allowing for usual slight variations this appears to be a Recent specimen of *H. (A). otwayanus*. The specimen is immature, measuring 3.8 mm max diam and 1.7 mm alt, and is slightly eroded.

H. (Awarua) otwayanus does not fully agree with the description and illustration, but appears close to *Heliacus aucklandicus* Marshall, from Pakaurangi Point, Kaipara Harbour, New Zealand (T.P.N.Z.I., 1918, vol. 50:263, pl. 18, fig. 2). Finlay, *ibid.*, 1927, Vol. 57, states also that *Heliacus aucklandicus* is very close to *H. marwicki* Allan.

Heliacus (Awarua) sp. Fig. 10 (19-21).

DESCRIPTION: *Protoconch* small, nucleus minute, regularly coiled, .76 mm diam. *Teleoconch* 5¼ flatly concave whorls, dorsum flatly convex, base of body-whorl flat, sloping inwards at 45° to outer edge of umbilicus. *Sutures* finely incised, scalloped, joined under edge of peripheral keel and whorls slightly imbricating. *Sculpture* of 5 gemmate cords and threads on dorsal surface of each whorl, and a flat trifid peripheral keel, whole surface crossed by numerous fine oblique axial striations, nodular at intersections with spirals; base with many fine spiral striations and threads of varying size, crossed by numerous very fine growth lines and a few larger scale-on-scale growth marks. *Umbilicus* commences at peak of shell base as a row of fine nodules not in form of a cord, over-ridden by 4 microscopic spiral threads, and is 66% of shell diameter at maturity; a further row of widely spaced small sharp nodules at base of wide concave umbilical area, and a third still finer row immediately below the first; umbilical canal slightly concave, crossed by numerous oblique microscopic growth lines. *Aperture* rhomboid, upper and outer lips straight, lower edge straight but sloping upwards at inner margin to meet straight but very oblique inner-lip.

LOCALITY: Aw. 1. Point Flinders, Cape Otway, Victoria. Grid ref. Aire 367,097. Glen Aire Clay: Aldingan?: Upper Eocene.

DIMENSIONS: Max diam 15.8 mm, min diam 13.5 mm, alt 5.7 mm, 5¼ whorls.

LOCATION OF SPECIMEN: Fossil Dept., N.M.V., Melbourne, Victoria, Reg'd No. P. 34816. Coll T. A. Darragh and T. Hughes 1/12/73.

MATERIAL: Single specimen only as above.

DISCUSSION: This species is very distinct and cannot be confused with any other, nor is it likely to be found to merge with other known species later when more material becomes available. Additional material is naturally necessary before naming it as a distinct species. The basal sculpture of the one Recent and two fossil species described in the genus *Awarua* is quite unique and not encountered elsewhere in the family.

Subgenus *CLARAXIS* Iredale, 1936:327. Type species by original designation *Claraxis illustris* Iredale, 1936 (=*Solarium asperum* Hinds, 1844).

REFERENCES: Wenz, 1938-44:668.

DIAGNOSIS: Small to medium, 3-15 mm diam, moderately to flatly depressed, nodular or gemmate sculpture dorsally and basally, umbilicus narrow to very wide, one sharp peripheral keel, no anal keel on protoconch, Operculum of many layers of chitinous material, medium to tall conical.

Heliacus (Claraxis) asperus (Hinds 1844) Fig. 6 (1-3, 12-14), 7 (1-6).

Solarium asperum Hinds, 1844a:23; 1844b:50, pl. 14, figs 9, 10.

Solarium dilectum Deshayes, 1863:68, pl. 9 (36), figs 3, 4-6.

Solarium (Torinia) dilectum. — Hanley (Sowerby), 1863:241, pl. 4, figs 50, 51.

Solarium (Torinia) asperum. — Hanley (Sowerby), 1863:241, pl. 5, figs 77, 78.

Torinia dilecta. — Marshall (Tryon), 1887:19, pl. 6, figs 91, 92; Bayer, 1948:15.

Torinia aspera. — Marshall (Tryon), 1887:21, pl. 6, figs 7, 8; Thiele, 1925:302, pl. 9, figs 8, 9.

Solarium (Torinia) admirandum Melvill and Standen, 1903:322. — Melvill, 1904:84, pl. 8, fig. 6.

Claraxis illustris Iredale, 1936:327, pl. 24, fig. 16.

DESCRIPTION: *Protoconch* regularly coiled, smooth and shining, varying .84-.98 mm diam. *Teleoconch* up to 6 flatly convex beaded whorls, convex base. *Sutures* strongly impressed at outer edge of canal between whorls. *Sculpture* of 4 or 5 narrow beaded spiral cords encompassed on outer margin by a similar larger cord; 2 or 3 finer beaded cords lie in an excavation between this outer cord and peripheral keel, which is strongly crenulate; whole sculpture is crossed by numerous fine axial grooves; adjoining peripheral keel on base are 4 or 5 fine beaded cords rising towards top of convex section, followed by 3 larger similar cords, with a fine thread between, and adjoining umbilicus; whole base of shell is crossed axially by crowded fine grooves. *Umbilicus* very widely perspective, averaging 46% of shell diameter at maturity, bordered by strong sharply serrated umbilical cord; umbilical canal strongly obliquely striated on concave base. *Aperture* sub-circular, crenulated exteriorly by cords, and with narrow grooves behind peripheral keel and at base of inner-lip, which is inclined to right basally. *Colour* white, tinged in some specimens with very pale fawn on a few cords in an irregular manner. *Operculum* elongate cone-shaped; solid yellow material covered with clear gelatinous substance formed into 16 sharp-edged separate fins encircling central core; fine spiral peg-shaped attachment at rear.

TYPE LOCALITY: Straits of Macassar, 20 metres.

DIMENSIONS: Holotype, max diam 9.5 mm, alt 3.2 mm. Largest specimen examined, max diam 15.8 mm, min diam 13.5 mm, alt 7.6 mm, 6 whorls. (Rocky Point as below).

LOCATION OF TYPE: B.M.N.H., reg'd No. 79:2:26:159.

DISTRIBUTION: On west coast, 3 localities near Eaglehawk Is., and Delambre Is., Dampier Archipelago (approx. 20° 35′ S., 116° 38′ E.), 40 metres; south and eastwards on south coast of Western Australia, 121 km E. of Rocky Point (33° 43′ S., 125° 04′ E.), 77-80 metres; eastwards and north to Port Hacking, New South Wales, south of Port Jackson, 100 metres; north to Narrabeen, north of Port Jackson (33° 39′ S., 151° 17′ E.), 146 metres (greatest depth recorded); northwards to Cape Moreton, southern Queensland, (27° 02′ S., 153° 28′ E.), 114-124 metres; northwards round Cape York and west to Arafura Sea, 160 km N. of Croker Is., Northern Territory (9° 30′ S., 132° 34′ E.), 124 metres. Moderate to deep water and only obtainable by dredging. Distributed round whole Australian coastline and northwards through Indonesia to type locality. Also found in Victorian Tertiary.

MATERIAL: Dampier Achipelago as above, 3 specimens June 1960, W.A.M. Reg'd Nos. 92-93-94/73; off Rocky Point as above, 1 specimen, coll CSIRO 7/7/1962, H.M.A.S. *"Gascoyne,"* (G2/104/62), A.M. No. C. 91977; off Port Hacking as above, 21 specimens in 4 lots, various depths down to 100 metres; E. of Narrabeen as above, 1 specimen coll Prof. Haswell 1907, A.M.No. C. 25833; off Cape Moreton as above, 1 specimen ex T. A. Garrard coll, A.M. No. C. 91976; Arafura Sea as above, 6 specimens coll P. H. Colman 9/11/69, M.V. *"San Pedro Sound,"* (B.M.R. Stn. P69-1144), A.M. No. C. 91978. A.M. and W.A.M. 53 specimens (24 lots). Also 1 specimen Tawitawi Is., Sulu Archip., Philippine Is., 16-23 metres, coll B.R. Wilson 24/2/1964, *"Pele"* — Sulu Exped., W.A.M. No. 91-73.

FOSSIL SPECIMENS: 5 specimens, cliff-face S. of Grice's Creek, Mornington Penin., Victoria, ex J. Kerslake and T. A. Garrard coll, A.M. No. C. 94474. Grid ref. Cranbourne 106, 903. Upper Balcombe Clay: Bairnsdalian: Middle Miocene. 2 specimens, Fossil Beach, Mornington Penin., Victoria, ex J. Kerslake and T. A. Garrard coll, A.M. No. C. 94475. Grid ref. Cranbourne 072,845. Balcombe Clay: Balcombian: Middle Miocene.

DISCUSSION: Recent specimens show a few slight varitations from fossil specimens, however these features are variable and overlap in both Recent and fossil specimens, and are not sufficient and consistent enough to warrant separation.

Specimen mentioned under "Material" W.A.M. No. 94-73 from Dampier Archipelago, W. Australia, is shining white, almost translucent; it has fine fawn spots on cord above peripheral keel, and also on larger inner cord bordering concave section, but absent from the 3 others between them.

Heliacus (Claraxis) aequatorialis (Thiele, 1925). Fig. 9 (13-15).

Torinia aequatorialis Thiele, 1925:268 (302), pl. 9 (21), figs 8,9. — Bayer, 1948:4.

DESCRIPTION: *Protoconch* regularly coiled, smooth and shining, very small, .45 mm diam. *Teleoconch* 3 whorls, flatly convex dorsally, base convex, prominet beaded peripheral keel. *Sutures* joined at edge of peripheral keel, at base of narrow canal. *Sculpture* of narrow oblique axial riblets on first whorl, between prominent beaded cords on either margin; after first whorl the axial riblets together with a further cord then develop into 2 cords of obliquely placed square or rectangular nodules; a deep groove, axially striated and pitted, between outer beaded cord and peripheral keel, which is strongly beaded; basally 3 or 4 strong beaded cords, interstices equal in width to cords; followed by 2 stronger squarely noduled periumbilical cords; main umbilical cord broad,

rounded and gross, with large elongate rounded nodules, 7 on last whorl. *Umbilicus* narrow and deep, barely perspective, 21% of shell diameter; umbilical canal flat-based, axially striated by growth lines. *Aperture* circular internally, strongly crenulated exteriorly by cords; inner-lip arcuate, glazed, and partly reflected over umbilicus. *Colour* opaque white. *Operculum* not available.

TYPE LOCALITY: "From Padang (Sumatra) and from East Borneo."(Author).

DIMENSIONS: Holotype, max diam 3.7 mm, alt 1.8 mm, 3 whorls. Apparently average adult size.

LOCATION OF TYPE: Humboldt University Museum, East Berlin, Reg'd No. ZMB Moll. 101908.

DISTRIBUTION: On known records appears to be confined to northern Australia, Indonesia and Borneo (Sabah).

MATERIAL: Unique specimen, 9 metres Van Diemen's Inlet, Gulf of Carpentaria (16° 59′ S., 140° 59′ E.), coll C. Hedley, A.M. No. C. 15376. (Max diam 3.8 mm, min diam 3.3 mm, alt 1.8 mm).

DISCUSSION: The only specimen held is taken to be *H. (Claraxis) aequatorialis* (Thiele) rather than *H. (C). gemmulata* (Thiele), chiefly on account of the 3 whorls in a diam of 3.7 mm, corresponding with measurements of the holotype, and also on account of the Padang-East Borneo type locality. The only real difference between the within species and *H. (C). gemmulata* (Thiele) from Madagascar, apart from 5 whorls in an equal width, appears to lie in the peripheral keel, and the Australian specimen is closer to *H. (C). gemmulata* in this respect, otherwise it agrees well with the figure and description of *H. (C). aequatorialis*. Owing to the great variations which occur in many species in the sub-family, the two may later prove to be conspecific if and when a quantity of good material becomes available.

Heliacus (Claraxis) colmani sp. nov. Fig. 5 (4-6).

DESCRIPTION: *Protoconch* 1½ whorls, not inflated, regularly coiled, varying .38-.77 mm diam. *Teleoconch* depressed, 2½ flatly convex whorls with strong gemmate peripheral keel. *Sutures* sharply incised, irregular in outline, joined at edge of peripheral keel. *Sculpture* of 4 or 5 beaded spiral cords, those on both margins the strongest; below outer cord a strong beaded peripheral keel, separated from cord above by a wide deep channel; outer sculpture on base consists of 3 or 4 finely beaded cords, inside these a heavier cord , from which the surface is almost flat or steeply ramped, with one further finely beaded cord adjoining the crenulated umbilical cord. *Umbilicus* narrowly or widely perspective, average 29% of shell diam at maturity; umbilical cord sharply and widely crenulated; umbilical canal wide and deep with vertically striated concave base. *Aperture* circular with thin outer-lip strongly crenulated by external cords. *Colour* opaque or translucent white. *Operculum* not available.

TYPE LOCALITY: 370 km W. of Roebuck Bay, Western Australia (18° 30′ S., 118° 03′ E.), 238 metres.

DIMENSIONS: Holotype, max diam 4.8 mm, alt 1.8 mm, 2½ whorls. Largest specimen examined.

LOCATION OF TYPE: A.M., Sydney, Reg'd. No. C. 97687.

DISTRIBUTION: From type locality eastwards to Arafura Sea, 160 km N. of Croker Is., Northern Terrritory (9° 30′ S., 132° 34′ E.), 124 metres, eastwards to Murray Island, Torres Strait (9° 58′ S., 144° 02′ E.), 9-15 metres; southwards to Cape Sidmouth, north Queensland, beach collected (13° 29′ S., 143° 37′ E.). Shallow water to 238 metres. Appears to be an endemic Australian species.

MATERIAL: Type locality as above, holotype coll P.H. Colman 11/10/68, M.V. *"Espirito Santo,"* B.M.R. Stn. E68-576. Arafura Sea as above, 3 specimens coll P. H. Colman 9/11/69, M.V. *"San Pedro Sound,"* B.M.R. Stn. P69-1144, A.M. No. C. 97688; Murray Island as above, 1 specimen coll C. Hedley, A.M. No. C. 97689; Cape Sidmouth as above, 1 specimen coll A. U. Henn, A.M. No. C. 2668 (pt). A.M. 6 specimens (4 lots).

DISCUSSION: In some specimens the spiral cords consist of oblique beads following each other in direct lines from one cord to another, but no striations are visible in interstices. In others, oblique axial striations cross over the spiral cords and interstices from the upper suture, round the peripheral keel to the umbilicus. This unique variation in sculpture has not been observed in any other species.

This new species is named for Phillip H. Colman, Dept. of Malacology, Australian Museum, Sydney.

The nearest congener to this new species is *H. (Claraxis) foveolatus* (Tate), and although the two species are very similar basally, *H. (C). foveolatus* differs in having a smaller protoconch, varying from .37 to .51 mm diam, compared with .38 to .77 mm diam in this new species, and in lieu of the 5-6 cords including peripheral keel on each whorl in the new species, has only 4 cords followed by a wide concave space, then the peripheral keel on a lower plane, which causes a wide canal at the suture. The umbilicus on *H. (C). colmani* also averages only 29% of shell diameter at maturity, diameter being 4.8 mm, as against an average of 44% in *H. (C). foveolatus* with a diam of 5 mm.

Heliacus (Claraxis) foveolatus (Tate, 1893). Fig. 5 (10-12), 6 (15-17).

Torinia foveolata Tate, 1893:191, pl. 1, fig. 13.

Heliacus foveolatus. — Hedley, 1900:93; Cotton and Godfrey, 1933:73, pl. 1, fig. 2.

Torinista laseronorum Iredale, 1936:327.

DESCRIPTION: *Protoconch* smooth and shining, regularly coiled, varying .37-.51 mm diam. *Teleoconch* 3 whorls, flat-topped, rounded on base, one strong peripheral keel, light fawn periostracum. *Sutures* well impressed at base of narrow canal. *Sculpture* of 3 strong rounded spiral cords on each whorl crossed by equally strong axial ribs, 30-40 on body-whorl, 20-28 on penultimate, nodular at intersections, leaving deep square pits between; one similar cord in centre of ramp above peripheral keel, which is strongly beaded; sculpture on base of 5-6 similar spiral cords of varying strength, and similarly cancellated by axials. *Umbilicus* widely perspective, averaging 44% of shell diam at maturity, bounded by a strong umbilical cord crossed by axial riblets; crenulations on umbilical cord heavy and rounded; umbilical canal wide and shallow, with 2 strong spiral cords crossed by oblique axial riblets, nodular at intersections. *Aperture* circular, crenulated exteriorly by cords and peripheral keel. *Colour* opaque white or clear and glass-like. *Operculum* roundly conical with hollow tip, composed of layers of thin chitinous material with ragged edges, and the usual peg-like projection at rear attached to foot of mollusc.

TYPE LOCALITY: Aldinga Bay, South Australia (35°21′S., 138°24′E.)

DIMENSIONS: Holotype, max diam 5 mm, min diam 4.25 mm, alt 1.75 mm. Largest specimen examined, max diam 4.7 mm, min diam 4 mm, alt 1.9 mm, 3 whorls, ex C. F. Laseron coll, Pittwater, New South Wales.

LOCATION OF TYPE: S.A.M., Adelaide, South Australia, reg'd No. D. 14331.

DISTRIBUTION: From Murray Is., Torres Strait (9°55'S., 144°05' E.), southwards along Queensland and New South Wales coasts, then westwards along Victorian coast at least as far as Arno Bay, South Australia (33°54' S., 136°34' E). Intertidal to 20 metres (3 specimens, Port Curtis, Queensland). On present records appears to be an endemic Australian species.

MATERIAL: Murray Is. as above, 1 specimen coll C. Hedley, A.M. No. C. 92488. Lady Elliott Is., Queensland (24°07' S., 152°42' E), 1 specimen coll C. Hedley, A.M. No.C. 8837 (pt). Caloundra, Queensland (26°48 S., 153°08' E.), 1 specimen coll C. Hedley, A.M. No. C. 12590. Woolgoolga, New South Wales, (30°07' S., 153°12' E.), coll C. F. Laseron, A.M. No. C. 92028, and 1 specimen coll T. Iredale same locality. Various specimens from Pittwater and Port Jackson, New South Wales, and Arno Bay, South Australia, as above, 7 specimens ex T. A. Garrard coll. A.M. No. C. 92026. Total specimens examined from all Australian Museums 86 (27 lots).

DISCUSSION: Basal area in this species from peripheral keel to umbilicus varies from flatly rounded to flat, in the form of a ramp, giving a V-shaped appearance to base of shell. Besides a deeply pitted appearance in the sculpture of this species, other differences between it and its nearest congener, *H. (C). colmani* Garrard nov., are described under "Discussion" following description of that species.

Heliacus (Claraxis) fragilis (Hinds, 1844). Fig. 8 (1-9).

Solarium fragile Hinds, 1844a:24; 1844b:51, pl. 14, figs 15, 16; 1844c:439. — Philippi, 1853:20, pl. 3, fig. 9.

TYPE LOCALITY: North coast of New Guinea, 13 metres.

DIMENSIONS: Holotype, max diam 6.3 mm, alt 2.1 mm.

LOCATION OF TYPE: B.M.N.H., Reg'd No. of 3 syntypes 1879:2:26:160-161-162.

DISCUSSION: Apparently this species is not recorded from Australia, despite the relatively short distance from the type locality. Photographs of the 3 syntypes have been furnished by B.M.N.H. and are therefore shown at fig. 8 (1-9) to assist with recognition. A letter from B.M.N.H. states regarding *Solarium fragile* that . . . "there is no evidence to suggest that Hinds selected any one as a holotype even though only one was figured. It is likely that Hinds had access to all three specimens when he described the species, hence they probably represent a syntypic series." However, the measurements of none of the 3 syntypes as shown by the mm scale taken with the photographs and now shown on the figure caption agree with the holotype measurements shown by the author.

The original Latin description of the colour pattern in this species indicates that cingula on both inner and outer margins of whorls are painted or ornamented with a dark colour, those between being pearly in appearance.

Heliacus (Claraxis) sp. Fig. 9 (25-27).

DESCRIPTION: *Protoconch* 1½ whorls, smooth and shining, inflated, .69 mm diam. *Teleoconch* 2¼ whorls, convex dorsally, very convex basally, unicarinate. *Sutures* deeply impressed, joined at base of peripheral keel and slightly imbricating. *Sculpture* dorsally of 5 spiral cords, separated from peripheral keel by a fine gemmate thread; cords cut into rhomboid segments by numerous oblique axial grooves; axial striae thus formed become bifid or trifid half-way across whorls, and over-ride peripheral keel, extending across base almost to umbilicus, total of 165 on body-whorl; base has 10 cords and threads between peripheral keel and a strongly crenulated umbilical cord, the numerous fine axial threads forming minute nodules at intersections. *Umbilicus* narrow but perspective, 30% of shell width, 3 periumbilical cords visible throughout; umbilical canal convex and irregularly striated by growth lines. *Aperture* sub-circular, grooved behind peripheral keel; outer-lip crenulated by cords, inner-lip arcuate and recurved. *Colour* white, tinged with fawn on peripheral keel. *Operculum* not available.

LOCALITY: 160 km N. of Croker Island, Northern Territory (9°30′ S., 132°34′ E), 124 metres.

DIMENSIONS OF SPECIMEN: Max diam 5.3 mm, min diam 4.2 mm, alt 2.6 mm, 2¼ whorls.

LOCATION OF SPECIMEN: A.M., Sydney, Reg'd. No. C. 100514.

DISTRIBUTION: Above locality only.

MATERIAL: Specimen is unique.

DISCUSSION: Although only one specimen of this apparently new species is held, it is included owing to its fine condition and unique type of sculpture, the unusually numerous and fine threads extending unbroken across both dorsum and base not being observed on any other species.

Heliacus (Claraxis) sp. Fig. 9 (20-21).

DESCRIPTION: *Protoconch* 1½ whorls, clear and glass-like, smooth and shining, not inflated, .27 mm diam. *Teleoconch* 2 whorls, sharply convexly ridged dorsally, sharply convex at lower base, one sharp peripheral keel. *Sutures* joined at upper edge of peripheral keel, forming deep narrow canal at sutures. *Sculpture* of 4 strong spiral cords on dorsum, smooth and rounded, a smooth flat round-edged peripheral keel, four further smooth cords on outer edge below keel, central 2 weaker; below these are 2 stronger similar cords, angulating base of shell; usual crenulated periumbilical cord is replaced in this species by 2 more smooth cords descending into umbilicus; smooth rounded axial ribs, 22 on body-whorl, commence at sutural canal, crossing all spiral dorsal cords, peripheral keel and all basal cords deep into umbilicus; all cords and ribs are nodular at points of intersection. *Umbilicus* wide and perspective, approx 50% of shell diam. *Aperture* circular interiorly with fine groove behind peripheral keel, strongly crenulated exeriorly by cords. *Colour* translucent white. *Operculum* unknown.

LOCALITY: S.W. end of Garden Island, S. of Perth, Western Australia (32°13′ S., 115°41′ E.)

DIMENSIONS: Max diam 2.0 mm, min diam 1.7 mm, alt .8 mm.

LOCATION OF SPECIMEN: A.M., Sydney, Reg'd No. C. 105175.

DISTRIBUTION: Above locality only.

MATERIAL: Specimen is unique, coll W. F. & J. M. Ponder and N. Coleman, 31/1/72.

DISCUSSION: Although only one specimen of this minute species is held its appearance and construction are so unique it is considered that it should be placed on record. The strong cancellate form of sculpture leaves deep rectangular pits between ribs and cords, and forms a scalloped peripheral keel, whilst the replacement of the usual crenulated periumbilical cord by 2 further smooth spiral cords is a most unusual feature.

FOSSIL SPECIES

Heliacus (Claraxis) wannonensis (Tenison- Woods, 1879). Fig. 6 (9-11).

Solarium wannonensis Tenison-Woods, 1879:237, pl. 21, fig. 10.

DESCRIPTION: *Protoconch* regularly coiled, 2 whorls, smooth and shining, .66 mm diam. *Teleoconch* 3½ flatly convex whorls in diam of 6.3 mm, base roundly convex; canaliculate at sutures. *Sutures* finely incised, joined at top of peripheral keel, raised above it and forming a deep canal. *Sculpture* of 4 flattened cords of varying widths, cut into segments by deep oblique axial grooves, inclined to be gemmate; a strong gemmate peripheral keel is then separated from both dorsal and basal cords by deep axially striated grooves; up to 7 gemmate cords on base, with two further strong segmented cords surrounding the wide crenulated umbilical cord. *Umbilicus* widely perspective, averaging 33% of shell diameter at maturity; umbilical canal flat based and obliquely axially striated. *Aperture* sub-circular, grooved at top and base of arcuate inner-lip, and behind peripheral keel.

TYPE LOCALITY: Lower beds, Muddy Creek, near Hamilton, Victoria. Muddy Creek Formation: Balcombian: Middle Miocene.

LOCATION OF TYPE: A.M., Sydney, Reg'd No. F. 1818.

DIMENSIONS: Holotype, max diam 3.5 mm, alt 1 mm, 2¾ whorls. Largest specimen examined, max diam 6.3 mm, min diam 5.4 mm, alt 2.8 mm, 3½ whorls (topotype).

MATERIAL: Holotype, as above, and one topotype as above, A.M. Reg'd. No. F. 572.

DISCUSSION: A further new fossil species described and named in this revision, *Heliacus (Claraxis) morningtonensis* bears a strong general resemblance to *H. (C). wannonensis* and the differences between the two species are therefore set out below:

H. (C). wannonensis	*H. (C). morningtonensis*
Protoconch .66 mm diam	Protoconch .77-.85 mm diam
4 cords of nodules on dorsum	5 cords of nodules on dorsum
Deep narrow canal at sutures	No canal at sutures
Suture joined at top of peripheral keel and raised to level of previous whorl	Suture joined to edge of peripheral keel and not raised
8-9 cords of gemmules on base of varying widths	4 cords on base enclosing long close-packed axial bars towards umbilicus
2 shallow periumbilical sulci	1 deep narrow periumbilical sulcus
Umbilical cord with 20-22 crenulations on body-whorl	Umbilical cord with 15 heavy widely spaced crenulations on body-whorl

Heliacus (Claraxis) morningtonensis sp. nov. Fig. 9 (10-12).

DESCRIPTION: *Protoconch* regularly coiled, 2 whorls, raised slightly above first teleoconch whorl, smooth and shining, varying .77-.85 mm diam. *Teleoconch* flatly convex dorsally, 3¼ slightly convex whorls in diam of 5.8 mm, base roundly convex. *Sutures* strongly impressed at edge of peripheral keel. *Sculpture* of 5 cords on dorsum of oblique axially elongate nodules, including peripheral keel; 4-6 peripherad cords of nodules on base of varying widths, surrounding wide area of axial threads coalescing towards umbilicus to form broad closely packed axial riblets covering half the base of shell; a deep narrow sulcus separates these riblets from the umbilical cord. *Umbilicus* widely perspective, 32% of shell diameter at maturity; umbilical canal with slightly convex base, vertically striated; umbilical cord with 15 strong widely spaced pointed crenulations on body-whorl, and separated from adjoining riblets by a deep narrow sulcus. *Aperture* broadly ovate, narrowing towards peripheral keel and grooved behind it, a further groove at base of arcuate and reflected inner-lip; strongly crenulated by cords externally.

TYPE LOCALITY: Fossil Beach, Mornington Peninsula, Victoria. Grid ref. Cranbourne 072, 845. Balcombe Clay: Balcombian: Middle Miocene.

DIMENSIONS: Holotype, max diam 5.8 mm, min diam 4.5 mm, alt 2.9 mm, 3¼ whorls. Topotype 4.3 x3.8 x 1.8 mm, 2½ whorls.

LOCATION OF TYPE: A.M., Sydney, New South Wales, Malacology Dept., Reg'd No. C. 94485.

DISTRIBUTION: Type locality only at date.

MATERIAL: Holotype and one topotype as above, ex J. Kerslake — T.A. Garrard coll.

DISCUSSION: Both specimens are in perfect condition and a light overall fawn in colour. Although only the two are held it is considered that describing and naming as a new spedies is warranted owing to the many differences between this species and its closest congener, *H. (Claraxis) wannonensis* (Tenison-Woods), as described under "Discussion" following description of that species.

This new species also bears a resemblance to the recent *H. (Claraxis) fragilis* (Hinds, 1844), not recorded from Australia, but that species has a flatter base and a second periumbilical cord, whilst the basal riblets do not coalesce in the same manner. It also bears a strong resemblance to the Recent *H. (Torinista) dorsuosus* (Hinds, 1844) so far as the dorsal sculpture is concerned, but that species has a very different form of basal sculpture, with no coalescing riblets.

Heliacus (Claraxis) sp. Fig. 10 (13-15).

DESCRIPTION: *Protoconch* 1½ whorls, regularly coiled, smooth and shining, .64 mm diam. *Teleoconch* 5½ whorls in width of 12.2 mm, whorls flat-topped, dorsum convex, base convex, strongly unicarinate. *Sutures* joined at base of peripheral keel, strongly incised, whorls not imbricating. *Sculpture* dorsally of a strong nodular cord adjoining suture, then 2 rows of small nodules, followed by a further strong nodular cord; between latter cord and peripheral keel are 2 strong threads; peripheral keel solid on early whorls, but on body-whorl dividing into 6 compacted threads; whole dorsal surface crossed by strong oblique axial threads, becoming increasingly numerous on body-whorl, crossing peripheral keel and base to umbilicus; 6 strong cords on base; the whole sculpture carries elongate nodules on all cords where crossed by the axial threads.

Umbilicus widely perspective, 45% of shell diameter at maturity; umbilical cord strong with large axial nodules; umbilical canal convex, a sharp strongly raised cord near centre, one row of small nodules separating it from outer umbilical cord, whole area crossed by strong oblique axial threads. *Aperture* broadly ovate, narrow grooves behind peripheral keel and in centre of inner-lip, which is a little reflected.

LOCALITY: Probably from "Clifton Bank," near Muddy Creek, 6.4 km West of Hamilton, Victoria.

DIMENSIONS: Specimen max diam 12.2 mm, min diam 10.6 mm, alt 6.6 mm, 5½ whorls.

LOCATION OF SPECIMEN: A.M., Sydney, Reg'd No. C. 100602.

MATERIAL: Above specimen only.

DISCUSSION: This specimen was found with other material from Muddy Creek, Victoria, in the A.M. collection, and although without a separate label is almost certainly from the same locality. It has been placed on record owing to its near perfect condition and complete dissimilarity from all other fossil and Recent species.

Sub-family PSEUDOMALAXINAE

DIAGNOSIS: Shells small to extremely small, 1-13 mm major diam, discoidal in shape; whole base of shell forms umbilicus; aperture rounded internally, whorls quadrate externally; very little sculpture; no anal keel on protoconch; operculum chitinous, thin and flat.

Genus *PSEUDOMALAXIS* Fischer, 1885

PSEUDOMALAXIS Fischer, 1885:174. Type species by monotypy *Bifrontia zanclaea* Philippi, 1844.

REFERENCES: Monterosato, 1913:362; Cossmann, 1915: 122, 141; Thiele, 1931:184; Rehder, 1935:128; Wenz, 1939:668; Pilsbry and McGinty, 1945:9; Eames, 1952:37; Abbott, 1954:138-9; Maxwell, 1966:444; Merrill, 1970:42-7; Glibert, 1973:30; Buonaiuto, 1975:28.

SYNONYMS: *Discosolis* Dall, 1892. Type species by original designation *Omalaxis nobilis* Verrill, 1885. *Mangonuia* Mestayer, 1930. Type species by original designation *Mangonuia bollonsi* Mestayer, 1930.

DIAGNOSIS: As for that of sub-family above.

DISCUSSION: Use of the genus *Pseudomalaxis*.

A very comprehensive but unpublished PhD dissertation by A. S. Merrill, 1970, as shown in the "List of References," entitled "The family Architectonicidae in the western and eastern Atlantic," contains the following remarks on p. 43 — "The genus *Pseudomalaxis* is truly a stable one . . . The genus occurs in the deeper waters of the tropics and sub-tropics. The major features are the very flat spire, the squarish shape and tight coiling of the whorls, and the wide open umbilicus."

The disjunct range of similar or closely related species exhibited by a number of species in the family Architectonicidae is also exemplified in the genus *Pseudomalaxis* by the species *Pseudomalaxis nobilis* Verrill of the western Atlantic and West Indies, with the synonymous *P. actoni* Monterosato of the Mediterranean, also the very closely related *P. meridionalis* Hedley in Australia, with its synonyms *P. bollonsi* Mestayer in New Zealand and *P. solaris* Kuroda in Japan.

Pseudomalaxis (Pseudomalaxis) nobilis meridionalis (Hedley, 1903)
Fig. 6(4-5), 7 (10-12)

Omalaxis nobilis Verrill, 1885:423, pl. 44, fig. 12.

Omalaxis meridionalis Hedley, 1903:351, text fig. 74.

Discohelix meridionalis. — Iredale, 1911:256; Mestayer, 1916:125.

Mangonuia bollonsi Mestayer, 1930:144.

Pseudomalaxis solaris Kuroda, 1938a:1, text figs 1-3.

Pseudomalaxis (Mangonuia) solaris. — Kuroda, 1938b:61.

Mangonuia solaris. — Kuroda and Habe, 1954:81, 83, text fig. 3; Kuroda, Habe and Oyama, 1971:265, pl. 61, fig. 17.

Pseudomalaxis meridionalis. — Buonaiuto, 1975:28.

DESCRIPTION: *Protoconch* regularly coiled, varying .87-1.04 mm diam. *Teleoconch* discoidal, 4 flatly convex whorls, rising from nucleus to peripheral edge, sides flat but sloping inwards towards base, underside of whorls flatly convex with raised edges. *Sutures* incised, rough and irreguar, joined to whole peripheral area but beneath dorsal peripheral keel. *Sculpture* of 2 rough and irregular peripheral rows of axially elongate nodules, forming a bifid keel, a similar raised row of nodules close to inner margin, a number of microscopic spiral threads in flat space between, crossed by strong irregular and oblique growth lines; base of whorls with one strong irregularly crenulated peripheral keel, with flat or flatly convex central space sloping inwards to centre, and a narrow ramp sloping downwards to edge of adjoining whorl, the whole crossed by strong irregular oblique growth lines; outer-edge almost flat, sloping inwards from dorsum to base at 20-25°, 2 fine striae between upper and lower peripheral keels, with a third appearing occasionally only on body-whorl, space between keels crossed by strong vertical growth lines. *Umbilicus* consists of entire base of shell. *Aperture* sub-quadrate, rough and uneven, thickened at outer edge. *Colour* off-white, irregularly maculated with fawn or light brown, fawn spots at intervals on lower peripheral keel; covered with extremely thin fawn periostracum. *Operculum* composed of 5-6 extremely thin fawn layers of chitinous material, very thin overall, slightly concave, attached to foot of mollusc by central peg-shaped projection at rear, minute central perforation in nucleus.

TYPE LOCALITY: Port Stephens, New South Wales.

DIMENSIONS: Holotype, max diam 4.5 mm, min diam 3.6 mm, alt 1.25 mm. Largest specimen examined, max diam 13.3 mm, min diam 11 mm, alt 3.35mm, 4 whorls (Fig. 6 (4-5).

LOCATION OF TYPE: A.M., Sydney, Reg'd. No. C. 16298.

DISTRIBUTION: Off Moreton Bay, southern Queensland (27° 22′ S., 150°39′ E.), 77 metres, thence southwards to 29 km E.N.E. of Port Stephens, New South Wales (32°42′ S., 152°05′ E.) 113 metres, near type locality; Narrabeen, near Port Jackson, 146 metres; off Port Hacking, S. of Port Jackson, 82 metres; off Malabar, S. of Port Jackson, 137 metres. Only other known localities are northern New Zealand (*P. bollonsi* Mestayer) and Japan (*P. solaris* Kuroda).

MATERIAL: Off Moreton Bay as above, 1 specimen coll W. F. Ponder 29/3/69, H.M.A.S. *"Kimbla,"* A.M. No. C. 92043; E.N.E. of Port Stephens as above, 1 live specimen, coll P. Sadler, A.M. No. C. 90458; off Narrabeen as above, 2 specimens pres. Prof.

Haswell, A.M. No. C. 25834; off Port Hacking as above, 1 specimen ex T. A. Garrard coll, A.M. No. C. 92044; off Malabar as above, 1 specimen, A.M. No. C. 100777. Total A.M. 7 specimens (6 lots).

DISCUSSION: Holotype of *Mangonuia bollonsi* Mestayer has been examined at A.I.M. by Dr. W. F. Ponder, and compared with specimens of *P. (Pseudomalaxis) meridionalis* from New South Wales, proving to be conspecific. The 2 or 3 peripheral threads between keels referred to by Mestayer, also the position of the row of nodules on inner dorsal margin in relation to the periphery, both prove to be variable features; similarly the original comprehensive description and clear photos of *Mangonuia solaris* Kuroda leave no room for doubt that that species is also conspecific.

The live specimen of *P. (P). meridionalis* Hedley from New South Wales, Fig. 6(4-5) has been forwarded to Dr. Harald Rehder at the Smithsonian Institution, Washington, U.S.A., for comparison with the holotype of *P. (P). nobilis* (Verrill), and other specimens ranging from Chesapeake Bay to Barbados; the only consistent difference appears to be in the basal peripheral cord, which in *P.(P). meridionalis* is single and stout, whilst in *P. (P). nobilis* it is either bifid or trifid with the larger cord peripherad and the finer ones towards the umbilicus. The two species are so closely related that they must at least be considered sub-specific.

Pseudomalaxis (Pseudomalaxis) thetidis sp. nov.
Text figs la, b.

Omalaxis sp. Hedley, 1903:351.

DESCRIPTION: *Protoconch* 2 whorls, smooth, expanding rapidly in size, varying .52-.65 mm diam. *Teleoconch* 1½ whorls, peripheral area straight and vertical, strongly corded dorsally and basally, balance of whorls semi-circular. *Sutures* strongly incised at base of narrow deep canal. *Sculpture* of strong raised keels on both dorsal and basal outer margins, surmounted by widely spaced prominent axially elongate nodules, narrow and pointed; inner margin on both dorsum and base has fine narrow ridge, with or without sharp microscopic nodules; curved microscopic growth marks on all sides of whorls. *Umbilicus* consists of whole base of shell. *Aperture* circular internally except peripheral area, which is straight, conforming to outer-lip, which is thin and simple. *Colour* glass-like or opaque white.

TYPE LOCALITY: Off Cape Three Points, New South Wales (33°18′ S., 151° 30′ E.), 89-91 metres.

DIMENSIONS: Holotype, max diam 1.4 mm, alt .4mm, 1½ main whorls.

LOCATION OF TYPE: A.M., Sydney, Reg'd. No. C. 16297.

DISTRIBUTION: From 290 km W. of Broome, Roebuck Bay, Western Australia (18°25′ S., 119°50′ E.), 115 metres, to 160 km N. of Croker Is., Northern Territory (Arafura Sea), (9°30′ S., 132°34′ E.), 124 metres; 228 km North of Coburg Penin, Northern Territory (Arafura Sea), (9°09′S., 131°51′ E.), 220 metres; eastwards and south to Cape Three Points, New South Wales (33°18′ S., 151°30′ E.), 89-91 metres; E. of Narrabeen, near Port Jackson, New South Wales, 146 metres.

MATERIAL: W. of Broome as above, 1 specimen 6/10/68, M.V. *"Espirito Santo,"* B.M.R. Stn. E68-547, A.M. No. C. 97654. N. of Croker Is. as above, 5 specimens, coll P. H. Colman 9/11/69, M.V. *"San Pedro Sound,"* B.M.R. Stn. P69-1144, A.M. No. C. 92045. N. of Coburg Penin. as above, 1 specimen, coll P. H. Colman, 13/11/69, M.V. *"San Pedro Sound,"* B.M.R. Stn. P69-1167, A.M. No. C. 102588. Off Cape Three Points as above (type

locality) 1 specimen, coll C. Hedley, *"Thetis"* Exped., 1903. A.M. No. C. 16297. E. of Narrabeen as above, 2 specimens, coll Prof. Haswell, A.M. No. C. 25834 (pt). Total A.M. specimens 9 (5 lots).

DISCUSSION: The specimen referred to by Hedley (1903:351) from 49-50 fms off Cape Three Points, New South Wales, as "perhaps but not certainly the same species" as his *Omalaxis meridionalis* has been used as holotype for the within new species. Apart from its minute size it differs from *Pseudomalaxis meridionalis* in having only one dorsal peripheral cord in lieu of two, no spiral striae on periphery between dorsal and basal cords, and a deeper narrower canal at the sutures. The protoconch and 1½ adult whorls in this new species measure only 1.4 mm diam compared with 4.3 mm in a similar number of whorls in *P. meridionalis*. The protoconch in this new species also measures only .52-.65 diam compared with .87-1.04 mm diam in *P. meridionalis*.

The wide area of distribution as shown has been observed during the past few years in several other minute species in various families, possibly pointing to their existence in quantity in deep water over great distances round the Australian coastline.

FOSSIL SPECIES

Pseudomalaxis (Pseudomalaxis) praemeridionalis (Chapman, 1912) Fig. 10 (22-23)

Homalaxis praemeridionalis Chapman, 1912:189, pl. 12, figs 4-6; Iredale,1936:326.

Pseudomalaxis (Pseudomalaxis) praemeridionalis. — Buonaiuto, 1975:27.

DESCRIPTION: *Protoconch* regularly coiled, 1¾ whorls, .55 mm diam. *Teleoconch* 2¾ whorls, central dorsal surface concave, rising from protoconch to central gemmate cord on body-whorl, then again concave between this cord and peripheral keel; strongly angulately convex basally, *Sutures* strongly incised, joined at edge of peripheral keel. *Sculpture* consists of strong trifid peripheral cord, from which a narrow sulcus separates a flatly raised narrow cord, which becomes more rounded and prominent towards maturity; in centre of whorls is a prominent nodulose cord separated from peripheral area by a narrow concave section, crossed by rough and irregular growth lines; inner half of whorls flat, almost devoid of sculpture, and sloping down towards inner suture, where edge becomes raised to a slight smooth cingulum; basally the edge of shell slopes inwards at a sharp angle to a raised central cord crossed by numerous strong axially elongate nodules, from which the base continues upwards to the underside of protoconch, leaving base of whorls broadly V-shaped. *Umbilicus* consists of inner area of base inside the central gemmate cord on body-whorl. *Aperture* sub-circular, externally the whorl is contracted towards periphery; inner-lip arcuate and slightly reflected.

TYPE LOCALITY: "Blue Clays" of lower part, Altona Bay coal shaft, Altona Bay, Victoria. Newport Formation: Balcombian: Middle Miocene.

DIMENSIONS: Holotype, max diam 6.25 mm, min diam 5.5 mm, alt 1.75 mm, 1¾ whorls.

LOCATION OF TYPE: Fossil Dept., N.M.V., Melbourne, Victoria, Reg'd No. P. 12360.

MATERIAL: Holotype only specimen examined. One further specimen since found from Fossil Beach, Mornington Penin., Victoria. Grid ref. Cranbourne 072,845. Balcombe Clay: Balcombian: Middle Miocene. Max diam 9.8 mm, alt 3 mm. N.M.V. No. P. 34818. A third specimen held by S.A.M. from "Clifton Bank," Muddy Creek, near Hamilton, Victoria, Muddy Creek Marls: Balcombian: Early Middle Miocene. S.A.M. No. P. 18342.

DISCUSSION: The finding of 2 further specimens of this formerly unique species in widely scattered areas places it in much better perspective, and shows the very small variations in form and sculpture which occurred during its existence.

A comparison with *P. (P). nobilis meridionalis* shows that the latter has a broad plain slightly concave area adjoining the suture, rising to a low flatly-rounded area, which in turn is surrounded on a lower plane by a narrow roughly formed, axially striated area, adjoining the finely noduled peripheral keel. In *P. (P). praemeridionalis* the broad plain area is flat, and bounded on the outer margin by a raised sharply crenulated ridge; this ridge is then separated from the finely crenulated peripheral keel by a narrow concave area bearing 2-3 fine spiral threads. The peripheral edge in *P.(P) praemeridionalis* also slopes inwards to the base at a decidedly sharper angle, and the base is not so concave as that of *P. (P). nobilis meridionalis*.

Pseudomalaxis (Pseudomalaxis) asculpturatus Maxwell, 1966

Pseudomalaxis (Pseudomalaxis) asculpturatus Maxwell, 1966:444, figs 11-13; Buonaiuto, 1975:25, figs 1-3.

The above small species was described by Maxwell from McCullough's Bridge, New Zealand. Upper Waihao Greensand: Kaitan: Late Eocene.

Further specimens have since been found in the South Australian Adelaide Plains Sub-basin, Adelaide Childrens' Hospital bore No. 5. Blanche Point Marls: Aldingan: Late Eocene. The specimens are preserved in the collection of the Geological Survey of South Australia, Department of Mines, Adelaide, South Australia, Reg'd Nos. G.S.S.A.M. 3298-9, and M. 3300-3. Workers interested in the species are referred to the relevant publication by Buonaiuto.

Subgenus *SPIROLAXIS* Monterosato, 1913:363. Type species by monotypy *Spirolaxis centrifuga* Monterosato, 1890:161.

DIAGNOSIS: Shells minute, protoconch tightly coiled and bearing a varix at aperture, peritreme being entire; adult whorls disjunct, aperture semi-circular, straight or slightly concave on outer edge; peripheral cords dorsally and basally on outer margins of whorls, ornamentation on inner margins minute and spasmodic.

Pseudomalaxis (Spirolaxis) rotulacatherinea (Melvill and Standen, 1903)
Text fig. 2a, b.

Spirolaxis rotulacatherinea Melvill and Standen, 1903:299, pl. 21, fig. 3; Iredale, 1911:255 (*catherina* – error); Kuroda, 1938:3 (*catherina* — error).

DESCRIPTION: *Protoconch* smooth and shining, 2 whorls, tightly coiled, nucleus microscopic, .57 mm diam. *Teleoconch* 1½ whorls, detached, perimeter vertical but slightly concave, dorsum lightly ridged in centre, base flat, inner margin of whorls slopes downwards from dorsum and upwards from base towards centre at 45°, leaving narrow vertical central area; protoconch and first half teleoconch whorl raised above level of base of body-whorl. *Sutures* of protoconch strongly incised, no sutures on teleoconch. *Sculpture* — outer dorsal and basal peripheral cords flatly raised, surmounted by strong axially elongate widely-spaced nodules; inner dorsal cord of minute nodules; microscopic growth lines visible. *Aperture* five sided, outer-lip vertical, upper and lower horizontal, inner-lip arcuate, all thin and simple. *Colour* white and shining.

TYPE LOCALITY: Gulf of Oman (24°58′ N., 56°54′ E.), 285 metres.

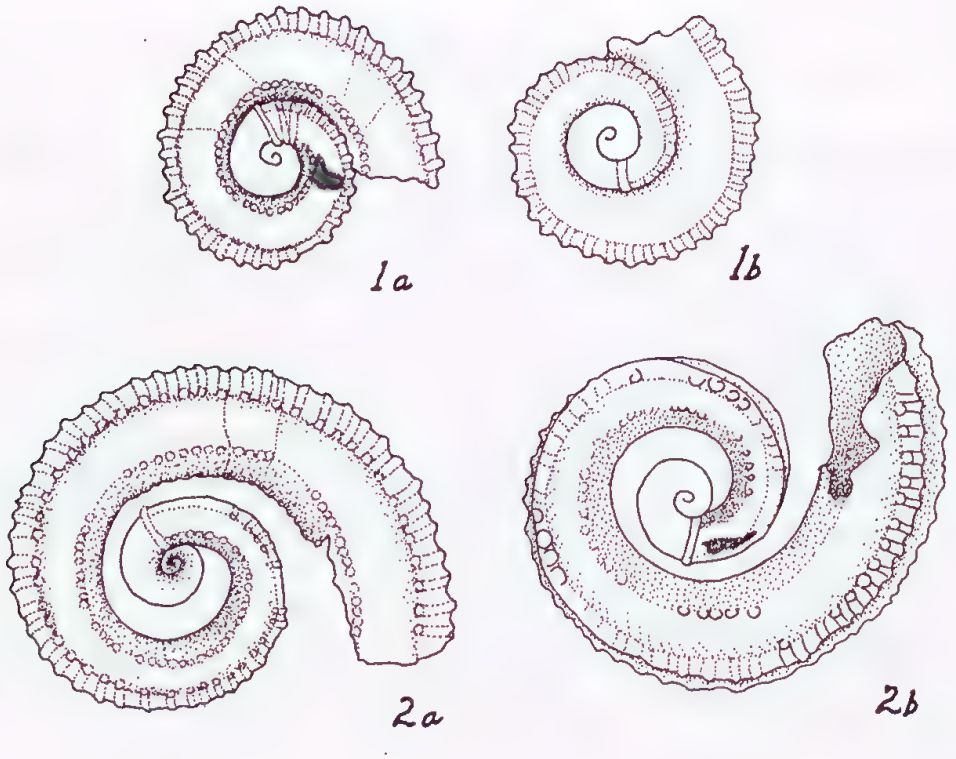
DIMENSIONS: Holotype, max diam 3 mm, alt 1 mm, 2 whorls.

LOCATION OF TYPE: B.M.N.H., Reg'd number not ascertained.

DISTRIBUTION: Only Australian locality on record is approx 238 km N. of Broome, Western Australia (14°50′ S., 121°49′ E.), 230 metres. Probably widespread throughout Indian Ocean.

MATERIAL: 1 specimen from above locality, coll 18/11/67, M.V. *"Kos 2,"* B.M.R. Stn. K67-205. (2.5 mm x .7 mm).

DISCUSSION: Authors state "Resembles *zanclaea* Philippi but more decicate in every detail." The original illustration shows the axial nodules on peripheral cords more closely spaced than those on the A.M. specimen, but this is most likely a variable feature.



(Pseudomalaxis). Fig. 1a, *Pseudomalaxis (Pseudomalaxis) thetidis* sp. nov. Holotype, dorsal view. 89-91 metres off Cape Three Points, New South Wales. X 22. Major diam 1.5 mm, alt.4 mm. A.M. No. C. 16297. 1b, *Pseudomalaxis (Pseudomalaxis) thetidis* sp. nov. Paratype, basal view. 228 km N. of Coburg Penin., Northern Territory, 220 metres. X 21. Major diam 1.5 mm, alt .4 mm. A.M. No. C. 102588. 2a, *Pseudomalaxis (Spirolaxis) rotulacatherinea* Melvill and Standen, 1903. Dorsal view. Fig'd spec 238 km N. of Broome, North-west Australia, 230 metres. X 21. Major diam 2.5 mm, alt .7 mm. A.M. No. C. 96365. 2b, *Pseudomalaxis (Spirolaxis) rotulacatherinea* Melvill and Standen, 1903. Basal view of fig. 2a. X 21. Barbara Duckworth del. Aust. Mus., Sydney.

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Valid names are in italics
*Denotes fossil species

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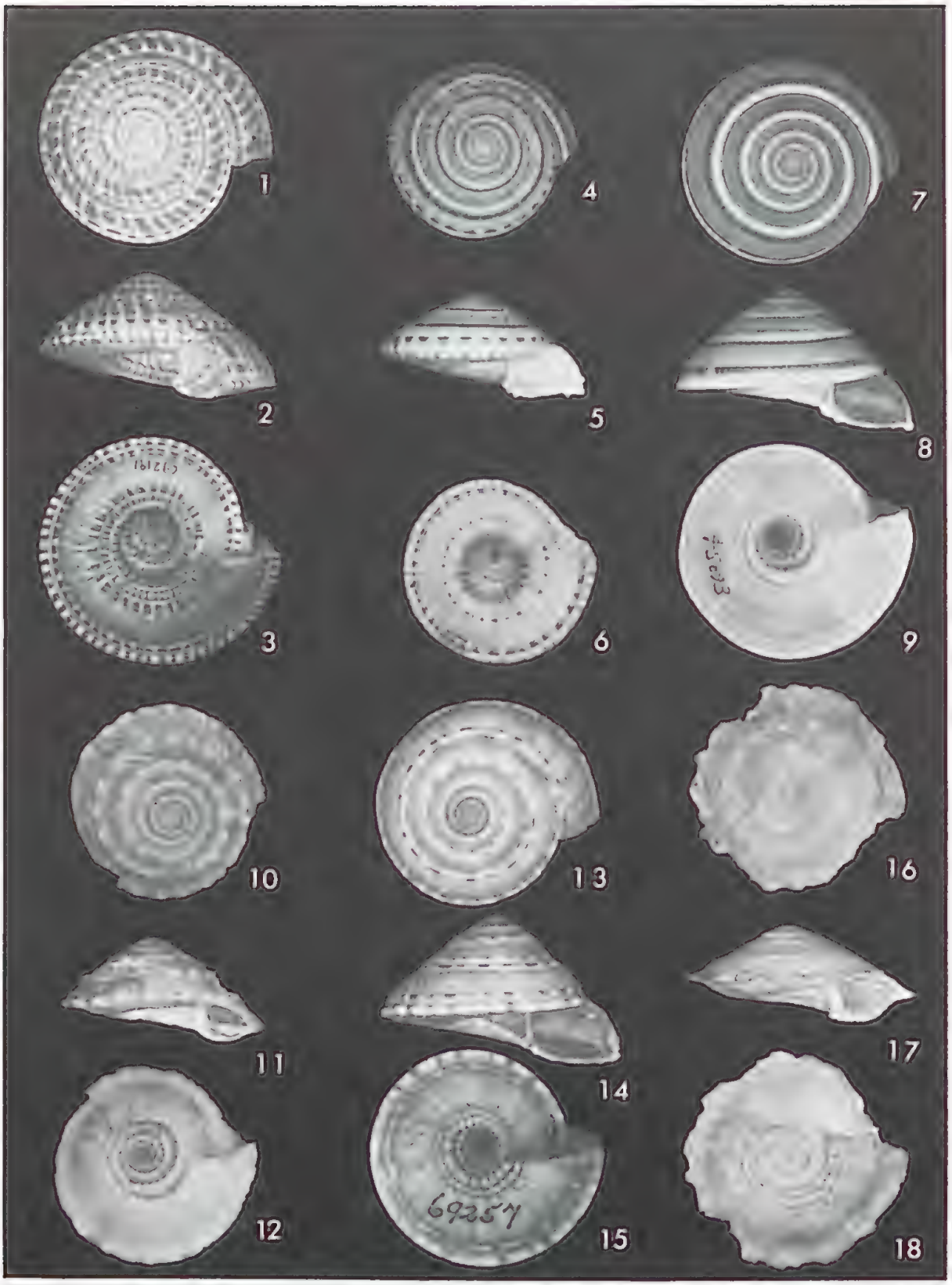

Fig. 1. (1-3) *Architectonica (Architectonica) perspectiva* (Linnaeus, 1758). Fig'd spec off Yamba, N.S.W., 37-49 met. Coll L.Bale (45.8 x 23.2 mm) X .82, A.M. No. C. 92121. (4-6) *Architectonica (Architectonica) perspectiva* (Linnaeus, 1758). Type of *A. (A.) perspectiva fressa* Iredale, 1936. Sydney Harbour, *"Triton"* dredge. (37.8 x 18.8 mm — amended) X .82. A.M. No. C. 60679. (7-9) *Architectonica (Architectonica) modesta* (Philippi, 1848) Fig'd spec, N. coast of P.N.G., coll W. Burrows (26.6 x 15.2 mm) X 1.35, AM. No. C. 45693. (10-12) *Architectonica (Discotectonica) kuroharai* Kuroda and Habe, 1961. Fig'd spec, N.E. of Cape Moreton, Q'ld, 114-124 met, coll T. A. Garrard)23.2 x 11.3 mm) X 1.33, A.M. No. C. 91663. (13-15) *Architectonica (Architectonica) perdix* (Hinds, 1844) Fig'd spec, Keppel Sands, Q'ld, coll P. H. Colman 14/1/59 (26.4 x 16.3 mm) X 1.4, A.M. No. C. 69257. (16-18) *Architectonica (Discotectonica) acutissima* (Sowerby, 1914) Type of *Russetia dilaniatus* Garrard, 1961. E. of Newcastle, N.S.W., 293 met, coll T.A. Garrard ex *"Challenge" (43 x 16 mm) X .84, A.M. No. C. 63345. All photos – Greg Millen, A.M., Sydney.*

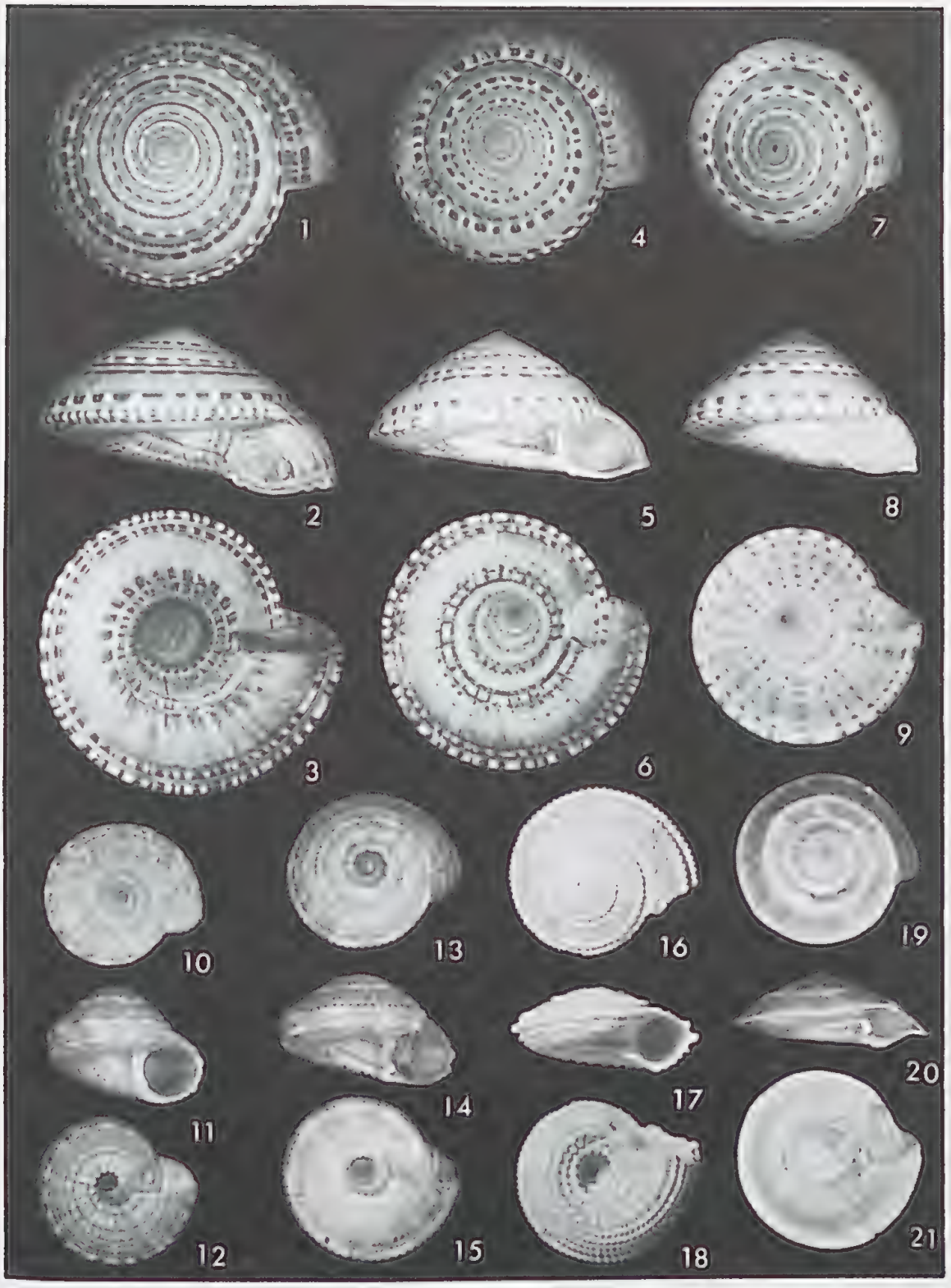

Fig. 2. *(1-3) Architectonica (Architectonica) perspectiva* (Linnaeus, 1758) Fig'd spec, off Trial Bay, N.S.W., ex J. Kerslake Coll (56.2 x 29.2 mm) X .83, A.M. No. C. 91673. (4-6) *Architectonica (Architectonica) maxima* (Philippi, 1848) Fig'd spec, off Wide Bay, Q'ld, 54 metres, ex T.A. Garrard coll (51.2 x 26.4 mm) X .82, A.M. No. C. 91665. (7-9) *Architectonica (Architectonica) maxima* (Philippi, 1848) Type of *A. (A). grandiosa* Iredale, 1931. Sydney Harbour, N.S.W., ex *"Triton"* dredge (43.2 x 24.3 mm — amended) X .83, A.M. No. C. 57773. (10-12) *Heliacus (Heliacus) cerdaleus ponderi* Garrard nov. Holotype, Long Reef, Collaroy, N.S.W., ex J. Kerslake coll (9.6 x 7.6 mm) X 2.71, A.M. No. C. 94479. (13-15) *Heliacus (Torinista) dorsuosus* (Hinds, 1844) Fig'd spec, North-West Is., Capricorn Group, Q'ld., coll T. Iredale, May 1929 (13.6 x 8.3 mm) X 2.1, A.M. No. C. 94386. (16-18) *Heliacus (Awarua) amoenus* (Murdoch and Suter, 1905) Fig'd spec, Arafura Sea, 160 km N. of Croker Is., Northern Terrtiory, 125 metres, coll P. H. Colman 9/11/69, M.V. *"San Pedro Sound"* (4.1 x 1.9 mm) X 7.3, A.M. No. C. 94341. (19-21) *Architectonica (Discotectonica) acutissima* (Sowerby, 1914) Fig'd spec, N.E. of Cape Moreton, Q'ld, 114-124 met, coll D. Harris (live) (36.1 x 14.1 mm) X .82, A.M. No. C. 91657. All photos — Greg Millen, A.M., Sydney.

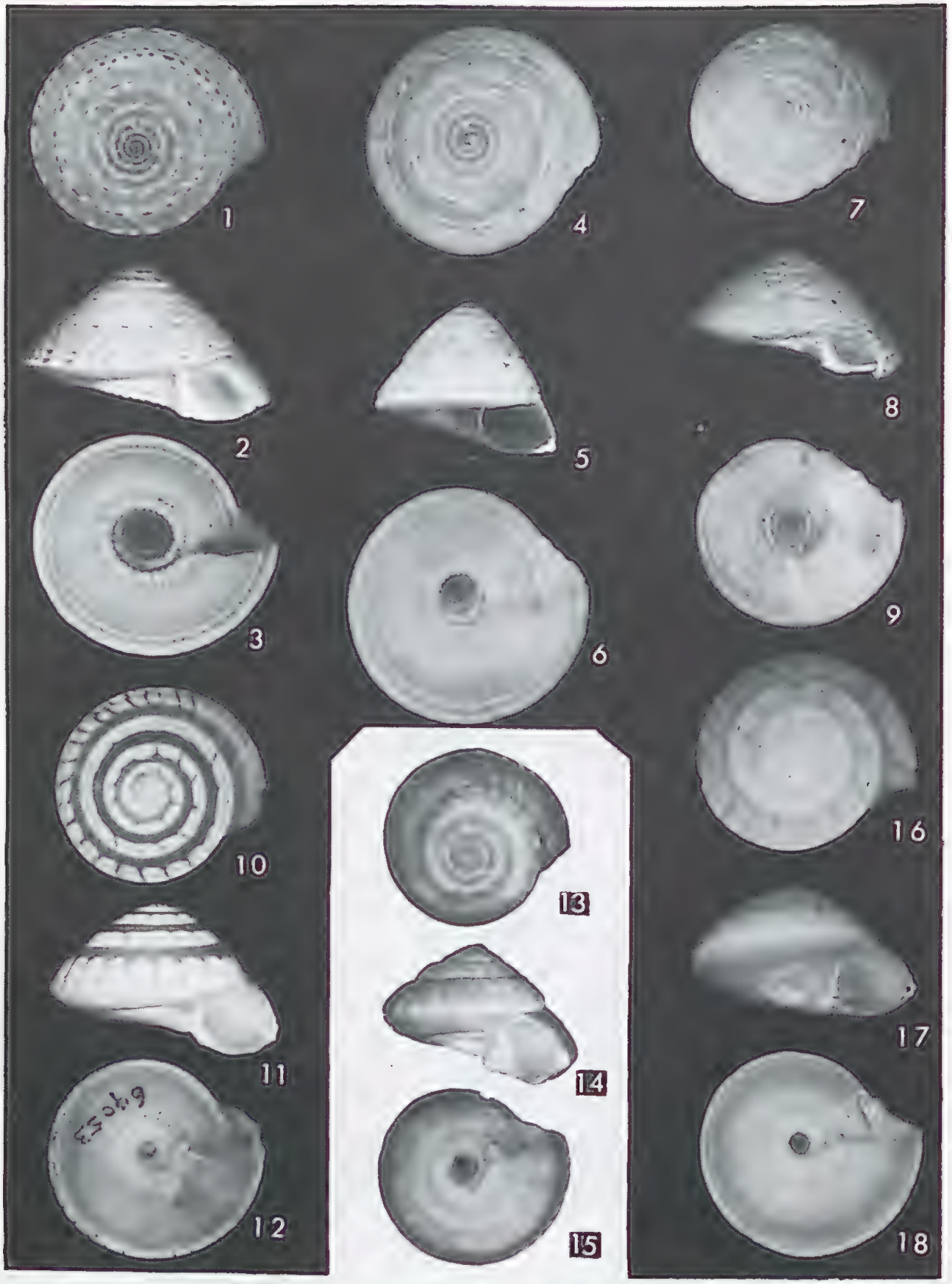

Fig. 3. (1-3) *Architectonica (Architectonica) reevei* (Hanley, 1862) Fig'd spec, off Port Kembla, N.S.W., 82 met, coll T. A. Garrard (27.5 x 17 mm) X 1.38, A.M. No. C. 96236. (4-6) *Architectonica (Architectonica) reevei* (Hanley, 1862) Type of *A. (A). offlexa* Iredale, 1931. Sydney Harbour, N.S.W. (20.2 x 16.2 mm — amended) X 1.88, A.M. No. C. 57774. (7-9) *Architeconica (Architectonica) reevei* (Hanley, 1862) Type of *A. (A). relata* Iredale, 1936. Off Bateman's Bay, N.S.W., 137-155 met (25 x 13.4 mm) X 1.3, A.M. No. C. 60680. (10-12) *Philippia (Psilaxis) radiata* (Roeding, 1798, Fig'd spec, Fairfax Is., Bunker Group, Q'ld. Coll J. Booth, 1968 (25.1 x 15.9 mm) X 1.37, A.M. No. C. 69053. (13-15) *Philippia (Psilaxis) radiata* (Roeding, 1798) Fig'd spec, Madang, P.N.G. (22.1 x 14.9 mm) X 1.35. (Contrasting colour pattern) ex T.A. Garrard coll, A.M. No. C. 96239. (16-18) *Philippia (Psilaxis) radiata* (Roeding, 1798) Type of *Philippia stipator* Iredale, 1931. Sydney Harbour, ex *"Triton"* dredge (17.1 x 10 mm) X 2.1, A.M. No. C. 93224. All photos — Greg Millen, A.M., Sydney.

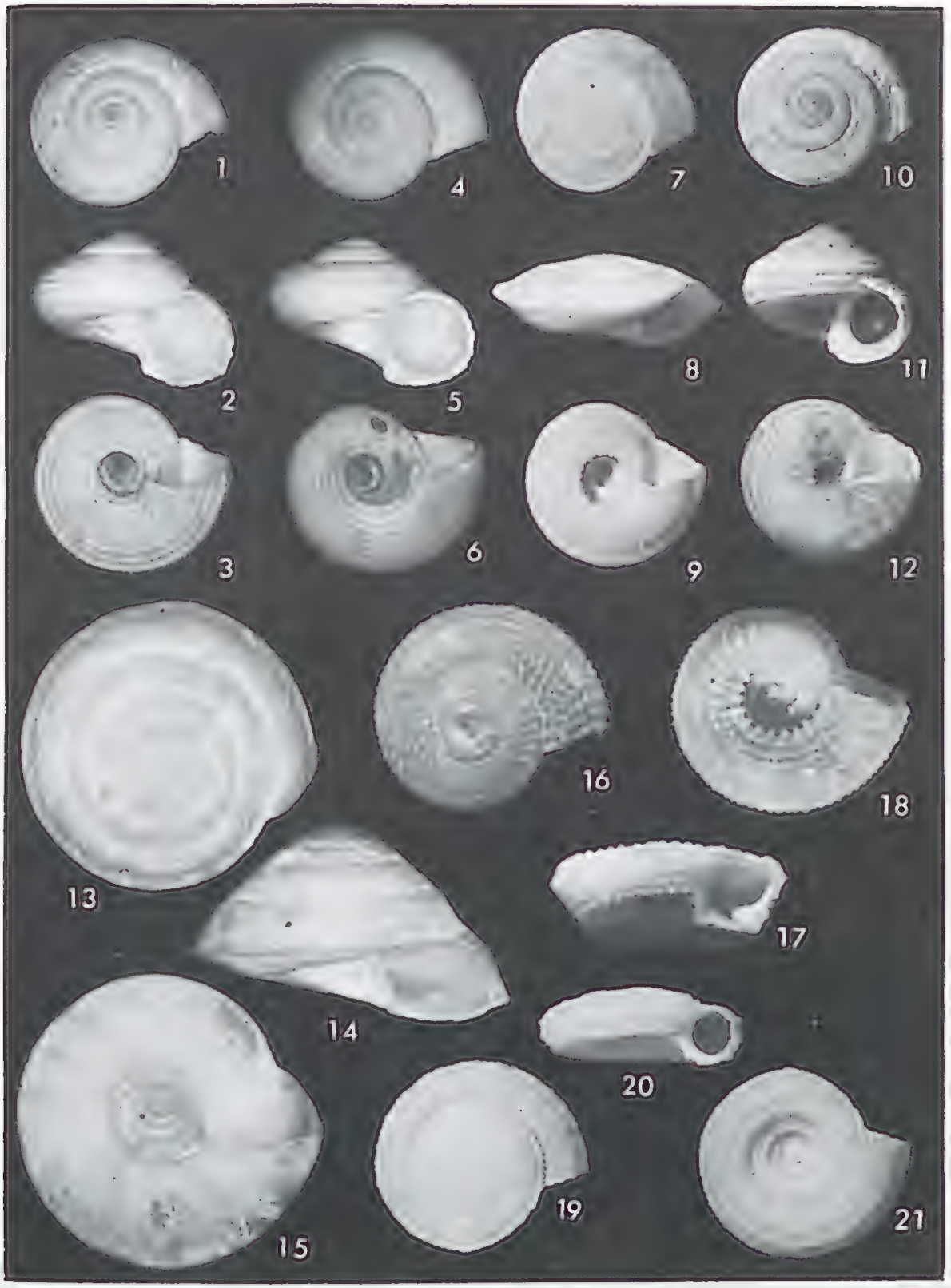

Fig. 4. (1-3) *Heliacus (Heliacus) stramineus* (Gmelin, 1791). Fig'd spec, off Island Head, 80 km N. of Yeppoon, Q'ld, 49 met, ex T.A. Garrard coll (38.4 x 26.9 mm) X .83, A.M. No. C. 92036. (4-6) *Heliacus (Heliacus) stramineus* (Gmelin, 1791) Type of *Grandeliacus mortensenae* Iredale, 1957. Hummock Hill Is., near Port Curtis, Q'ld. Coll Mrs. C. Mortensen, 1956 (38.4 x 26.8 mm) X .83, A.M. No. C. 96241. (7-9) *Architectonica (Solatisonax) atkinsoni* (E. A. Smith, 1891) Fig'd spec, S.E. of Lakes Entrance, Vic., 155 met, ex T. A. Garrard coll (6.3 x 2.8 mm) X 4.6, A.M. No. C. 96242. (10-12) *Heliacus (Heliacus) madurensis* (Schepman, 1909) Fig'd spec, S.E. of Bustard Head, Q'ld, 20 met, ex T. A. Garrard coll (6.9 x 5.5 mm) X 4.1, A.M. No. C. 91764. (13-15) *Architectonica (Solatisonax) injussa* (Iredale, 1931) Holotype, off Gabo Is., Vic., 183 metres, coll T. Iredale (25.4 x 15.4 mm) — amended, X 1.9, A.M. No. C. 57776. (16-18) *Heliacus (Torinista) concavus* (Thiele, 1918) Fig'd spec, off Bunbury, W. Aust., 156 met, coll CSIRO 10/8/62, H.M.A.S. "*Gascoyne*," Stn, G3/175/62 (2.5 x 1 mm), X 15.2, A.M. No. C. 94486. (19-21) *Heliacus (Torinista) fenestratus* (Hinds, 1844), Fig'd spec, Bird Is., Coral Sea, coll C. Hedley (9.3 x 3.8 mm) X 3.6, A.M. No. C. 8477. All photos — Greg Millen, A.M., Sydney.

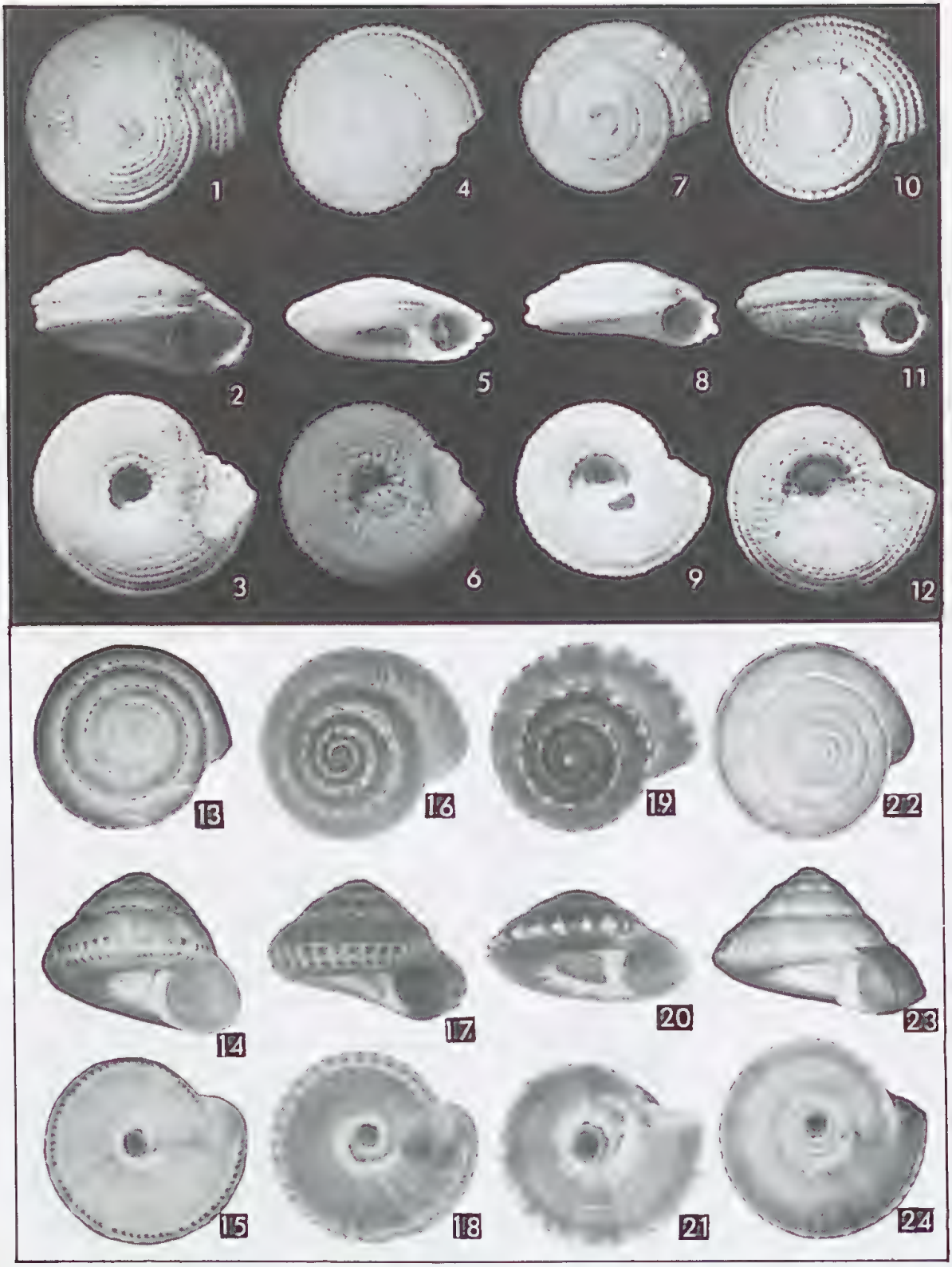

Fig. 5. (1-3) *Heliacus (Torinista) delectablis* (Melvill, 1893) Fig'd spec, Twofold Bay. N.S.W., coll Roy Bell (6 x 3.3 mm) X 6, A.M. No. C. 92021. (4-6) *Heliacus (Claraxis) colmani* Garrard, nov. Holotype. 370 km W. of Roebuck Bay, W. Aust., 238 met, coll P. H. Colman 11/10/68, M.V. *"Espirito Santo,"* B.M.R. Stn. E68/576 (4.8 x 1.8 mm) X 6.9, A.M. No. C. 96364. (7-9) *Heliacus (Torinista) costatus* (Schepman, 1899) Fig'd spec, Manly Beach, N.S.W., ex C. F. Laseron coll (5.2 x 2.4 mm) X 6, A.M. No. C. 92039. (10-12) *Heliacus (Claraxis) foveolatus* (Tate, 1893) Fig'd spec dredged Pittwater, N.S.W., ex C. F. Laseron coll (4.7 x 1.9 mm) X 7, A.M. No. C. 96258. (13-15) *Philippia (Philippia) lutea* (Lamarck, 1822) Fig'd spec, Huskisson, Jervis Bay, N.S.W., ex T. A. Garrard coll (15.7 x 12.5 mm) X 2.1, A.M. No. C. 96237. (16-18) *Philippia (Philippia) lutea* (Lamarck, 1822) Fig'd spec, Portland, Vic, ex T. A. Garrard coll (14.7 x 10 mm) X 2.3, A.M. No. C. 96238 (Dark grey form). (19-21) *Philippia (Psilaxis) oxytropis* (A. Adams, 1854) Fig'd spec, Woolgoolga, N.S.W., ex J. Kerslake coll (14.3 x 8.3 mm) X 2.4, A.M. No. C. 96240. (22-24) *Philippia (Psilaxis) oxytropis* (A. Adams, 1854) Holotype of *Philippia manifesta* Iredale, 1931. Sydney Harbour, N.S.W. (18.2 x 12.5 mm) — amended, X 1.8, A.M. No. C. 57775. All photos Greg Millen, A.M., Sydney.

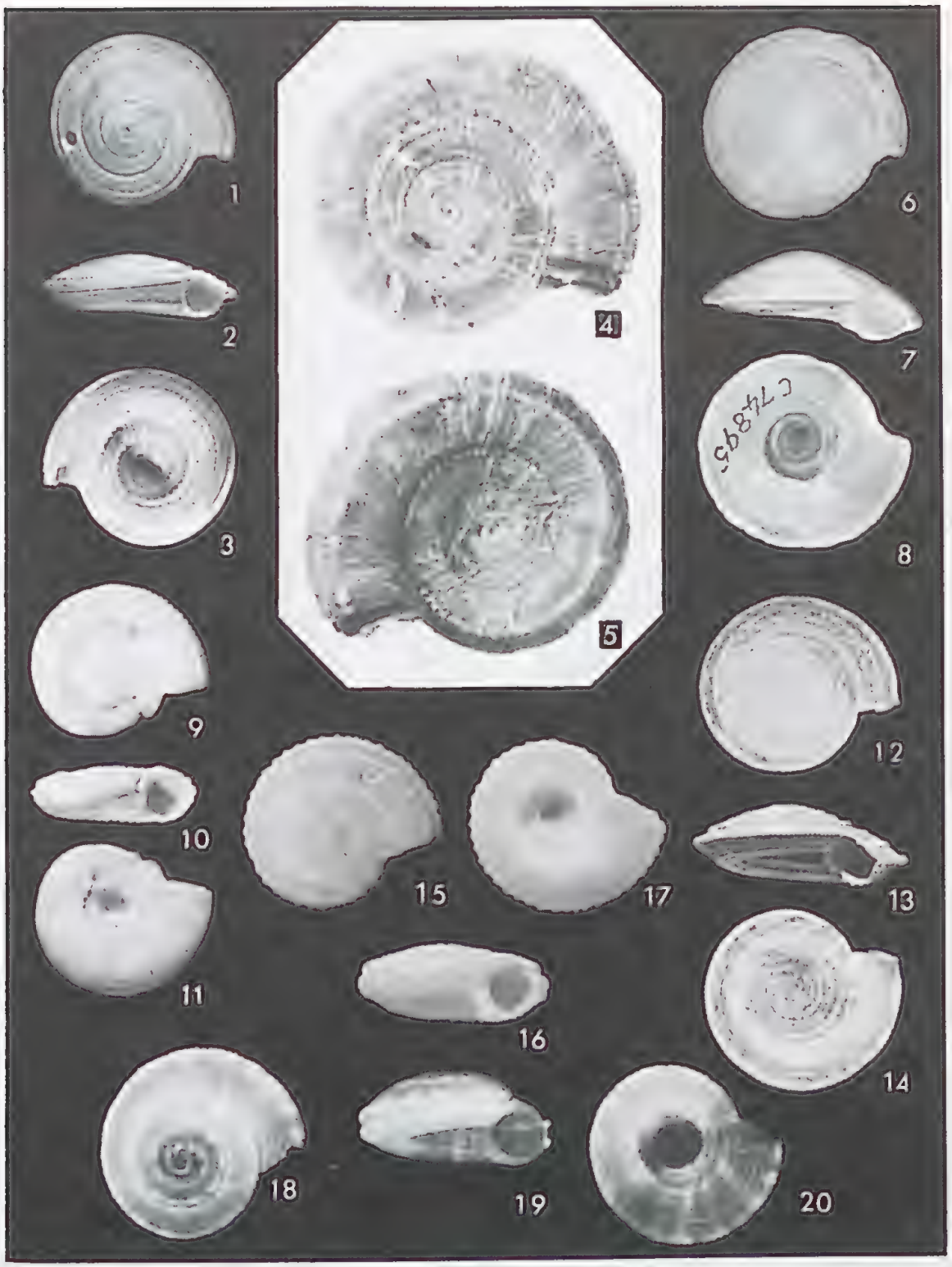

Fig. 6. (1-3) *Heliacus (Claraxis) asperus* (Hinds, 1844) Holotype, Straits of Macassar, 20 met (approx 9.5 x 3.2 mm) X 3.1, B.M.N.H. Reg'd No. 1879:2:26:159. (4-5) *Pseudomalaxis nobilis meridionalis* (Hedley, 1903) Fig'd spec, 29 km E.N.E. of Port Stephens, N.S.W., 113 met, coll P. Sadler (13.3 x 3.35 mm) X 4.1, A.M. No. C. 90458 (live). (6-8) *Architectonica (Discotectonica) balcombensis* (Finlay, 1927) Fig'd spec, Fossil Beach, Mornington Penin., Vic. Grid ref Cranbourne 072,845. J. Kerslake and T. A. Garrard coll (24.7 x 9.9 mm) X 1.4, A.M. No. C. 74895. (9-11) *Heliacus (Claraxis) wannonensis* (Tenison-Woods, 1879) Holotype. Lower beds, Muddy Creek, W. of Hamilton, Vic. Pres J. E. Tenison-Woods, 1892 (3.5 x 1 mm) X 11.1, A.M. No. F. 1818. (Holotype is worn). (12-14) *Heliacus (Claraxis) asperus* (Hinds, 1844) Fig'd spec, Cliffs S. of Manyung Rocks, Mornington Penin., Vic. Grid ref, Cranbourne 106, 903. J. Kerslake and T. A. Garrard coll (12.2 x 4.7 mm), A.M. No. C. 94474. (15-17) *Heliacus (Claraxis) foveolatus* (Tate, 1893) Holotype of *Torinista laseronorum* Iredale, 1936. Port Jackson, N.S.W., 26 metres (4.5 x 1.8 mm) X 7.3, A.M. No. C. 60693. (18-20) *Heliacus (Torinista) corallinus* Garrard nov. Holotype. Michaelmas Cay, Q'ld. Coll T. Iredale and G. P. Whitley, G.B.R. Boring Exp, May-June 1926 (5.7 x 2.8 mm) X 5.9, A.M. No. C. 94340. Photos — 1-3, B.M.N.H. 4-5, Chas Turner, A.M., Sydney. 6-17 Greg Millen, A.M., Sydney. 18-20, author.

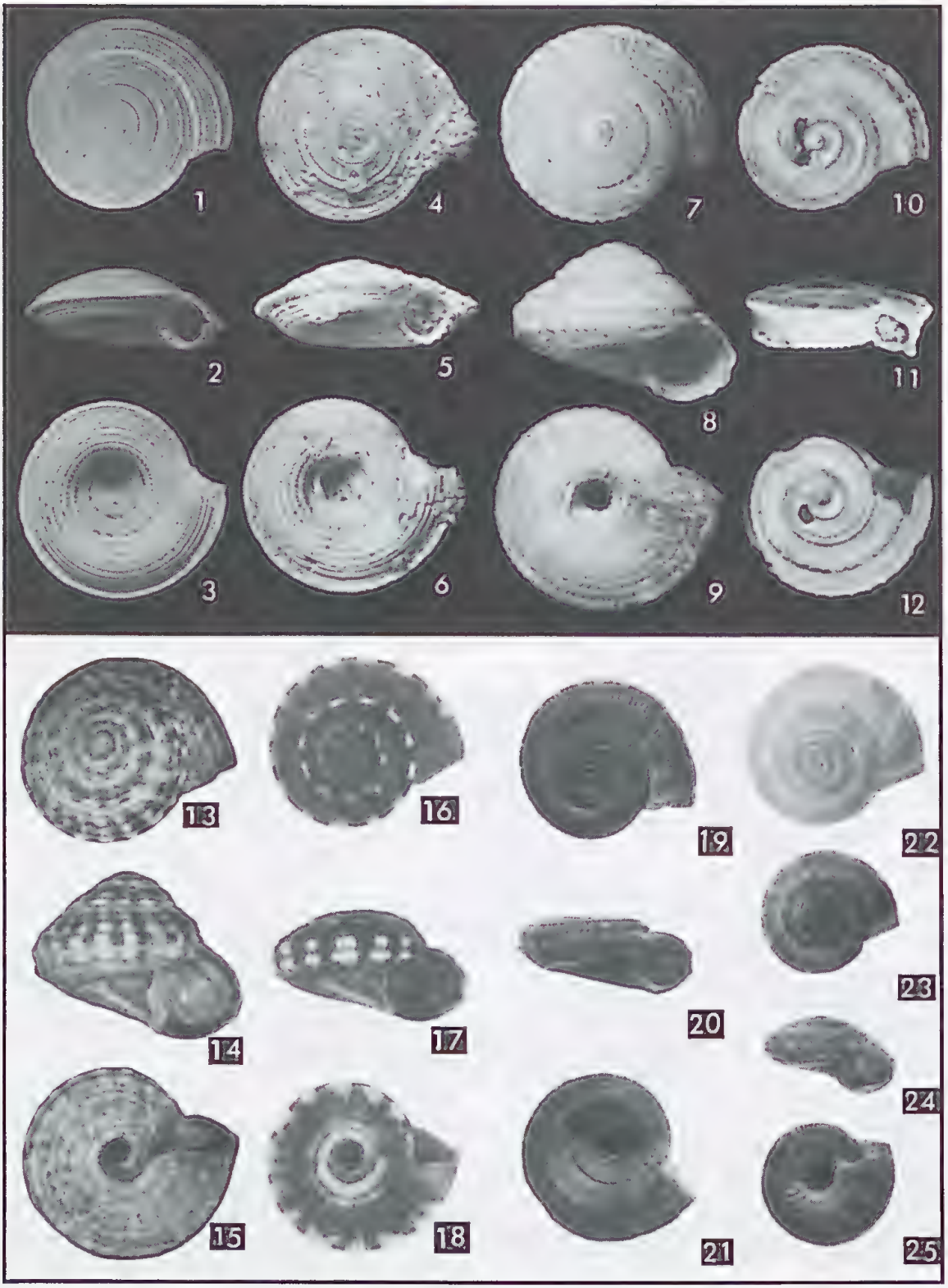

Fig. 7. (1-3) *Heliacus (Claraxis) asperus* (Hinds, 1844) Fig'd spec, off Port Hacking, N.S.W., 100 met, ex T. A. Garrard coll (13.2 x 5.7 mm) X 2.5, A.M. No. C. 96257. (4-6) *Heliacus (Claraxis) asperus* (Hinds, 1844) Holotype of *Claraxis illustris* Iredale, 1936, off Crowdy Head, N.S.W., 82 met, coll T. Iredale (7.5 x 3.3 mm — amended) X 4.4, A.M. No. C. 60694. (7-9) *Heliacus (Heliacus) mighelsi* (Philippi, 1853) Fig'd spec Lord Howe Is., coll J. Brazier (8.3 x 6.1 mm) X 4.3, A.M. No. C. 92405. (10-12) *Pseudomalaxis nobilis meridionalis* (Hedley, 1903) Holotype, Port Stephens, N.S.W., coll C. Hedley (4.5 x 1.25 mm) X 6.7, A.M. No. C. 16298. (13-15) *Heliacus (Heliacus) variegatus* (Gmelin, 1791) Fig'd spec, live — low tide, Wooli, N.S.W., ex T. A. Garrard coll (16.4 x 13 mm) X 2.1, A.M. No. C. 96250. (16-18) *Heliacus (Heliacus) variegatus* (Gmelin, 1791) Fig'd spec, Shelly Beach, Angourie, N.S.W., ex N. Jackson coll (13.2 x 8.8 mm) X 2.3, A.M. No. C. 96251 (depressed specimen, colour variation). (19-21) *Heliacus (Torinista) infundibuliformis* (Gmelin, 1791) Fig'd spec, Caloundra Beach, Q'ld, ex T. A. Garrard coll (12.7 x 5.9 mm) X 2.3, A.M. No. C. 92032. (22-25) *Heliacus (Heliacus) enoshimensis* (Melvill, 1891) Fig'd spec, East Ballina Beach, N.S.W., ex T. A. Garrard coll (8.3 x 4.5 mm) X 3.5 and 2.6, A.M. No. C. 91793. All photos — Greg Millen, A.M., Sydney.

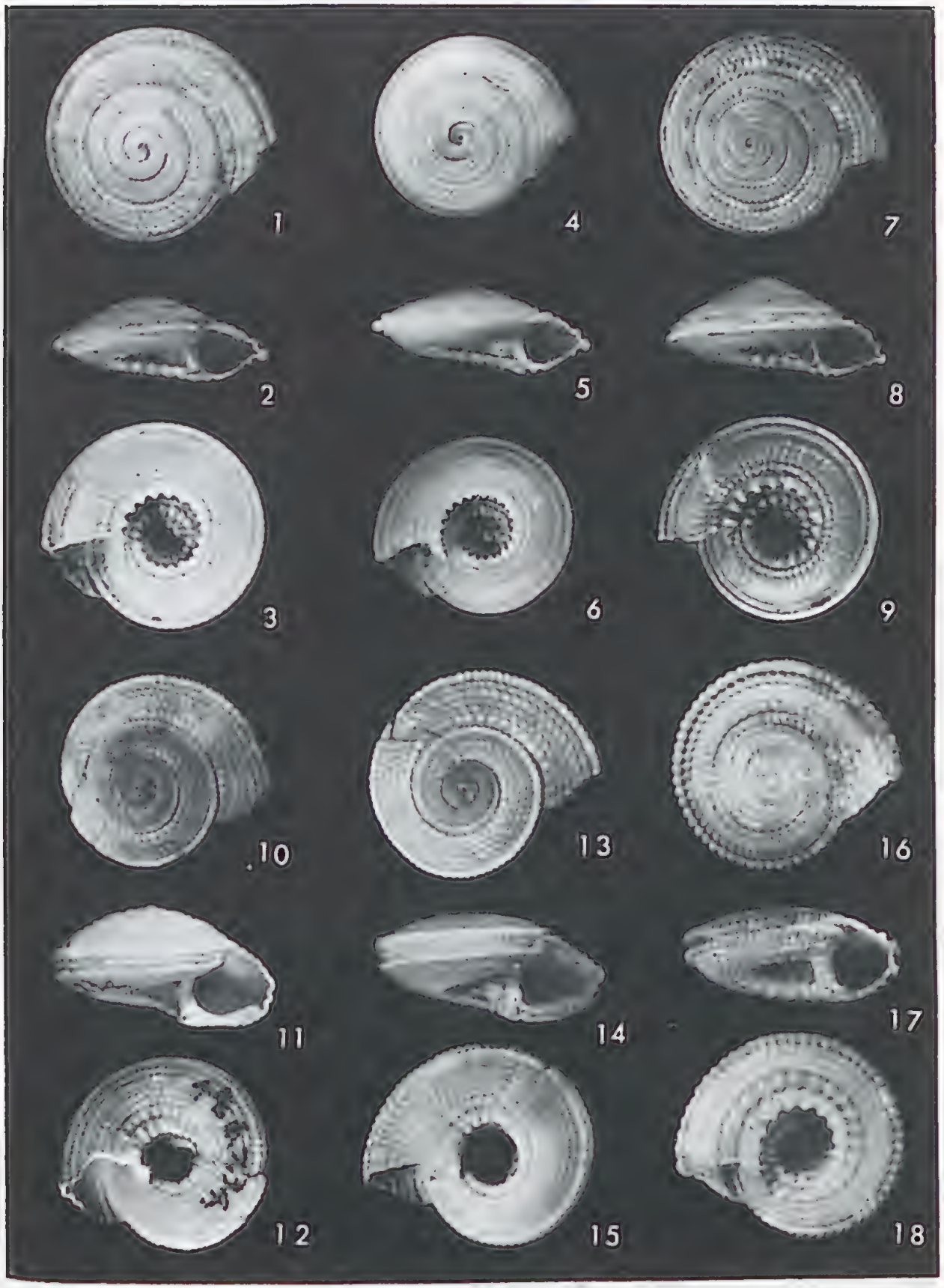

Fig. 8. (1-9) *Heliacus (Claraxis) fragilis* (Hinds, 1844), 3 syntypes B.M.N.H., Reg'd Nos. 1879: 2:26:160-162. North coast of New Guinea, 13 metres. Figs 1-3 approx 6.9 mm diam, 3.1 mm alt. 4-6 approx 5.9 mm diam, 2.5 mm alt. 7-9 approx 12.3 mm diam, 5.5 mm alt. (10-15) *Heliacus (Torinista) fulvus* (Hinds, 1844), 2 syntypes B.M.N.H. Reg'd Nos. 1844: 6:7:34. New Guinea. Figs. 10-12 approx 11.4 mm diam, 6 mm alt. Reg'd No. 1879: 2:26:158. Figs. 13-15 approx 8.4 mm diam, 4.1 mm alt. (16-18) *Heliacus (Torinista) virgatus* (Hinds, 1844), possible holotype B.M.N.H. Reg'd No. 1874: 12:11:190, approx 4.7 mm diam, 2.1 mm alt. (Author's measurements of holotype, 4.2 mm diam, 2.1 mm alt) New Guinea. All photos — B.M.N.H.

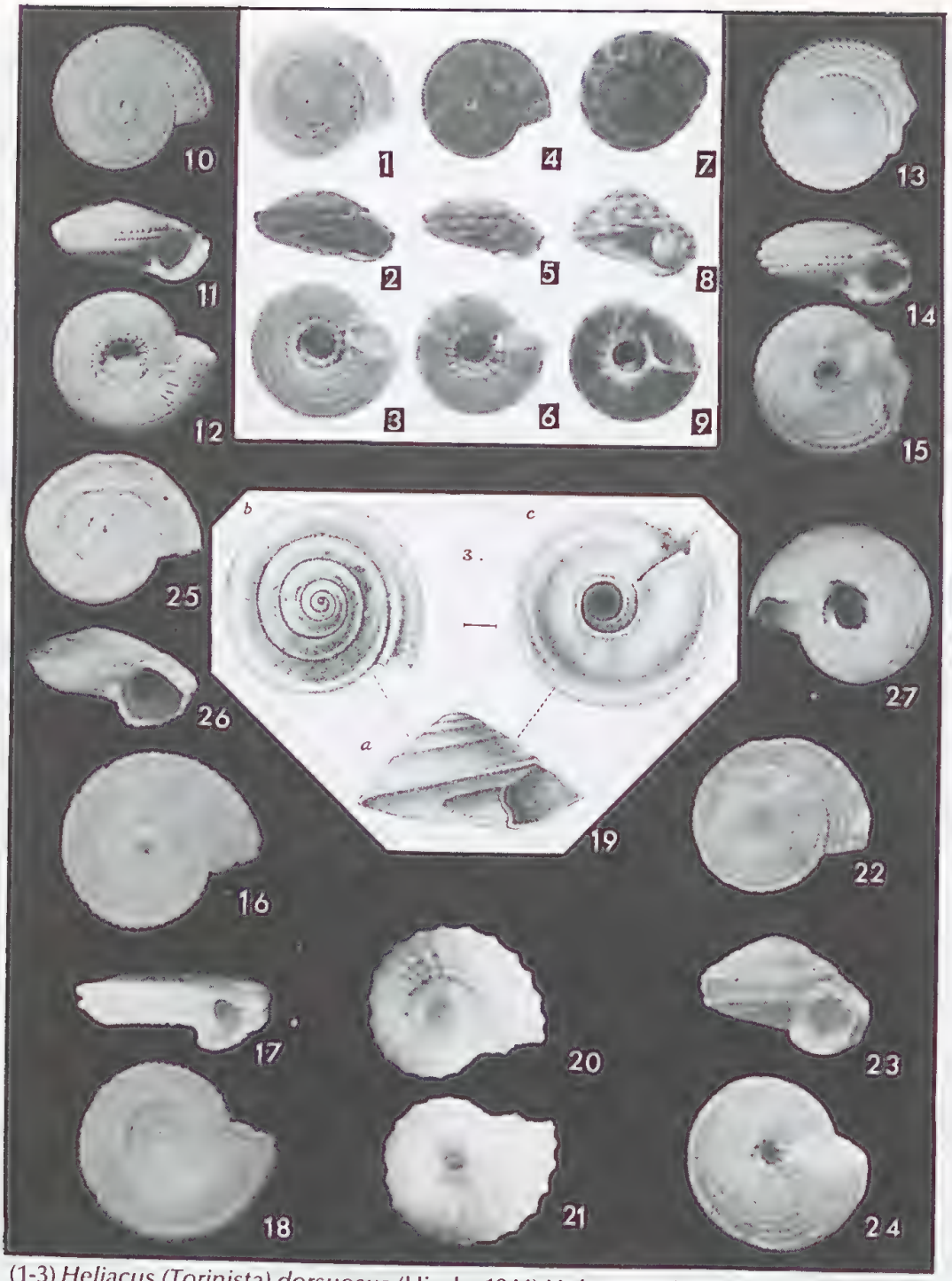

Fig. 9. (1-3) *Heliacus (Torinista) dorsuosus* (Hinds, 1844) Holotype of *Torinista popula* Iredale, 1936. Sydney Harbour, N.S.W., ex *"Triton"* dredge (9.2 x 4.6 mm — amended) X 2.6, A.M. No. C. 60692. (4-6) *Heliacus (Torinista) dorsuosus* (Hinds, 1844) Fig'd spec off Moreton Bay, Q'ld., 75-80 met, coll W. F. Ponder 29/3/69, H.M.A.S. *"Kimbla"* (8.2 x 3.9 mm) X 2.6, A.M. No. C. 96264. (7-9) *Heliacus (Heliacus) cerdaleus ponderi* subsp. nov. Fig'd spec, 3 km S. of Cape Naturaliste, W. Aust., coll W. F. Ponder and B. R. Wilson 3/1/72 (8.3 x 5.8 mm) X 2.6, A.M. No. C. 90978. (10-12) *Heliacus (Claraxis) morningtonensis* Garrard, nov. Holotype, Fossil Beach, Mornington Penin., Victoria, ex J. Kerslake, T. A. Garrard coll (5.8 x 4.5 mm) X 4.6, A.M. No. C. 94485. (13-15) *Heliacus (Claraxis) aequatorialis* (Thiele, 1925) Fig'd spec, 9 met. Van Diemen's Inlet, Gulf of Carpentaria, coll C. Hedley (3.8 x 1.8 mm) X 6.8, A.M. No. C. 15376. (16-18) *Heliacus (Torinista)* cf. *implexus* (Mighels, 1845) Fig'd spec, 31-37 met off Masthead Is., Q'ld., coll C. Hedley (4.5 x 1.5 mm) X 7.3, A.M. No. C. 19629. (19) *Architectonicinae sp. – trochiformis* (Schepman, 1909) Fig'd from author's orig. drawing — *"Siboga* Exped." 835 met, Ceram Sea (5 x 2.5 mm) X 6.6, (Vol 2:220, pl. 14, fig. 3). (20-21) *Heliacus (Claraxis)* sp. S.W. end of Garden Island, S. of Perth, Western Australia. Coll W. F. & J. M. Ponder, N. Coleman. (2 x .8 mm) X 14. A.M. C. 105175. (22-24) *Heliacus (Heliacus) hedleyi* Garrard nov. Holotype, Port Curtis, Q'ld., 13-18 met, coll C.Hedley (8.8 x 5.7 mm) X 3.3, A.M. No. C. 18727. (25-27) *Heliacus (Claraxis)* sp. Fig'd spec, 124 met, 160 km N. of Croker Is., Northern Territory (9°30'S., 132°34'E), coll P. H. Colman 9/11/69, M.V. *"San Pedro Sound"* (5.3 x 2.6 mm) X 5.5, A.M. No. C. 100514. All photos — Greg Millen, A.M., Sydney.

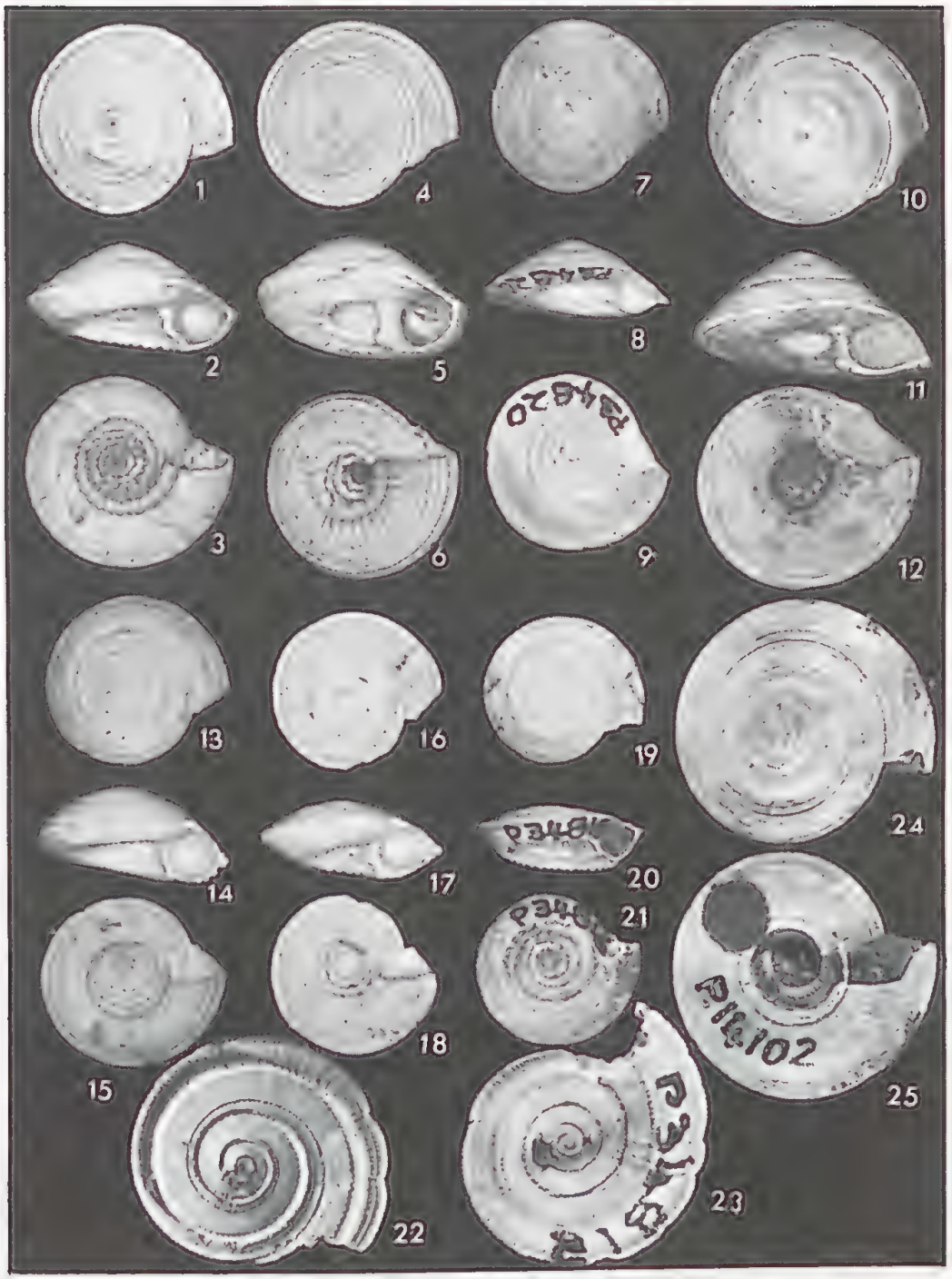

Fig. 10. (1-3) *Heliacus (Awarua) otwayanus* nov. Holotype. Aw. 1, Point Flinders, Cape Otway, Victoria. Grid ref. Aire 367, 097. Coll T. A. Darragh and T. Huges 1/12/72 (13.8 x 7 .1 mm) X 2.4, N.M.V. No. P. 31325. (4-6) *Heliacus (Torinista) darraghi* nov. Holotype. Aw. 1, Point Flinders, Cape Otway, Vict. Grid ref. Aire, 367, 097. Coll F. A. Cudmore (13.8 x 8.1 mm) X 2.4, N.M.V. No. P. 31321. (7-9) *Architectonica (Discotectonica) balcombensis* (Finlay, 1927) Neotype. Lower beds, "Clifton Bank," Muddy Creek, near Hamilton, Vic. Coll F. A. Cudmore 1922. (Major 17.5, Minor 16.5, Alt. 7 mm) X 1.6 N.M.V. No. P. 34820. (10-12) *Philippia (Psilaxis) mitchellana* nov. Holotype. Right bank of Mitchell River, "Moondara" farm Bairnsdale, Vic. 91 met N. of first gully south of house. Coll T. A. Darragh and K. Bell 3/5/71. (15 x 7.5 mm) X 2.4, N.M.V. No. P. 31314. (13-15) *Heliacus (Claraxis)* sp. Fig'd spec probably from Muddy creek, 6.4 km W. of Hamilton, Vic., locality doubtful. (12.2 x 6.6 mm) X 2.5, A.M. No. C. 100602. (16-18) *Architectonica (Discotectonica)* sp. Fig'd spec, just below high-tide mark, E. side of North Arm, below Ferndale Parade, Lakes Entrance, Vic. Grid ref. Bairnsdale 913, 276. Pres Mrs. M. Griffiths, Lakes Entrance, Vic. (11.5 x 4.9 mm) X 2.4, N.M.V. No. P. 31319. (19-21) *Heliacus (Awarua)* sp. Fig'd spec, Aw. 1, Point Flinders, Cape Otway, Vic. Grid ref. Aire 367, 097. Coll T. A. Darragh and T. Hughes 1/12/73 (15.8 x 5.7 mm) X 1.7, N.M.V. No. P. 34816. (22-23) *Pseudomalaxis (Pseudomalaxis) praemeridionalis* (Chapman, 1912) Holotype. Altona Bay Coal Shaft, Altona, Bay, Victoria. (6.25 x 1.75 mm) X 6.7, N.M.V. No. P. 12360. (24-25) *Architectonica (Architectonica) squamogranosa* (Chapple, 1941) Holotype. Lower beds, Muddy Creek, W. of Hamilton, Victoia. Coll E. H. Chapple (19 x 8 mm) X 2.2, N.M.V. No. P. 14102.

SOME POLYCLAD TURBELLARIANS NEW TO THE FAUNA OF THE AUSTRALIAN COASTS

STEPHEN PRUDHOE

Department of Zoology, British Museum (Natural History), London.

SUMMARY

This paper is a contribution to the knowledge of the polyclad turbellarians of the Australian coasts. Of the eleven species encountered and belonging to five known genera, one acotylean, *Hoploplana rosea,* and three cotylean species, one *Acanthozoon* and two *Pseudoceros,* are new, whilst six species have been described hitherto, but are new to the Australian fauna. Two specimens of the remaining form are very young, but appear to be unidentifiable stylochids.

INTRODUCTION

The collection described below was made by Neville Coleman, principally in 1972, and deposited in the Australian Museum, Sydney. With the exception of one specimen from Queensland, one from South Australia and another from New South Wales, the material was obtained from various localities along the shores of Western Australia. It is contained in 13 tubes, and unfortunately most of the forms are each represented by only one specimen, hence descriptions of the cotylean species, with one exception, are directed towards external features, with some observations made from a study of internal organs, as seen in whole mounts cleared in methyl salicylate.

A brief historical account of the earlier Australian studies of polyclad flatworms was given by Haswell (1907), who also added nine new species to the polyclad fauna of the eastern coast of Australia. This was followed by Bock's (1913) descriptions of two new species of the genus *Pseudoceros* from Western Australia. Subsequently, Stummer-Traunfels (1933) redescribed the type-material of species found in Australia by Schmarda (1859). Hyman (1954) added two new species of *Pseudoceros* from the Great Barrier Reef, and finally in 1959 she added seven more species to those known from the coast of New South Wales. Moreover, in a book by K. Gillett and F. McNeil (1959), there is on p. 112 a coloured plate of four kinds of polyclad turbellarians, which were unnamed, and which appear to have been found on the Great Barrier Reef. It seems that the figures from top to bottom represent: *Pseudoceros ferrugineus* Hyman, 1959; *Pseudoceros fuscopunctatus* sp.nov. (described below); *Pseudoceros corallophilus* Hyman, 1954, and *Pseudoceros bedfordi* Laidlaw, 1902.

Records of The Australian Museum, 1977, **Vol. 31 No. 14,** 586-604, Figures 1-8.

SYSTEMATIC ACCOUNT

ACOTYLEA

Family Stylochidae Stimpson, 1851
An undetermined genus and species Fig. 1

LOCALITY: Western Australia (on rubble in 25ft. at Hall's Bank, Fremantle, 13 April, 72.)

MATERIAL: 1 juvenile specimen (AM. reg.no. W5481)

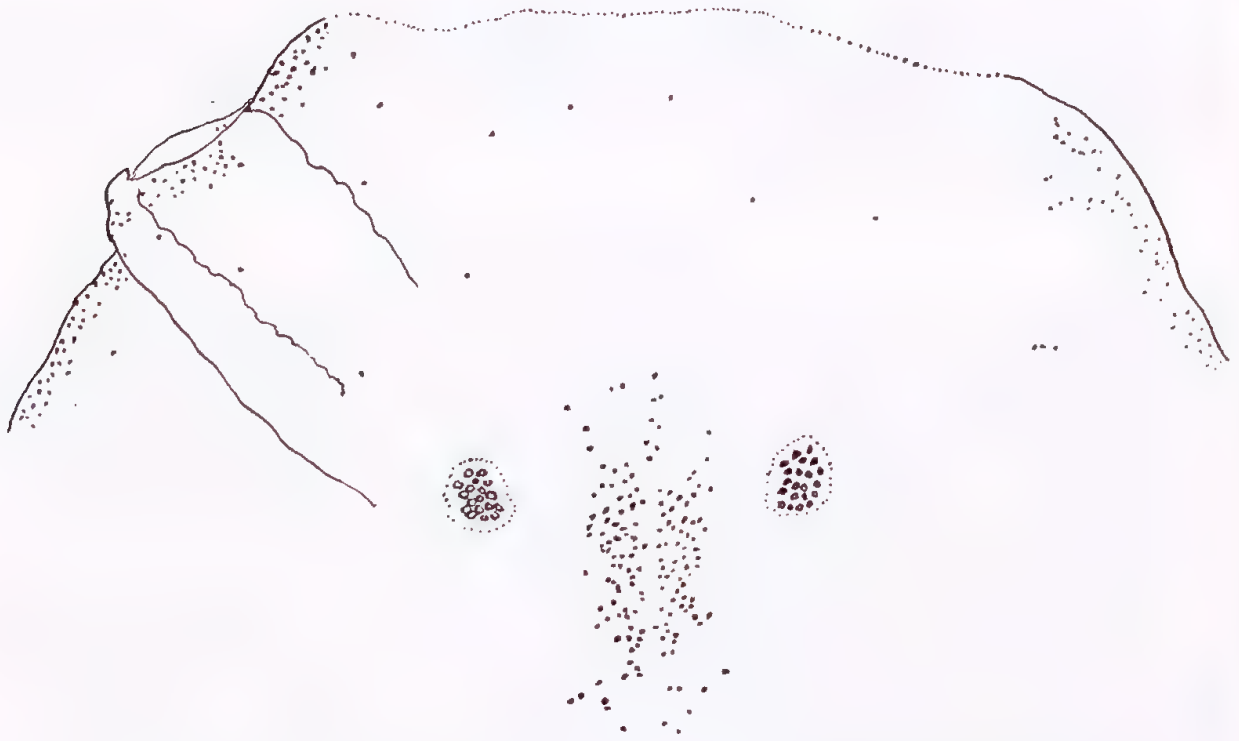

Fig. 1 Stylochid. Arrangement of eyes in anterior region (dorsal view).

This specimen is juvenile and rather obovate in outline, although the body is damaged along the anterior margin. It measures 12 mm in length and 9 mm in maximum width, which occurs in the middle region of the body. The ruffled pharynx is everted through the mouth and forms a rosette just behind the middle of the body. As shown in fig. 1, eyes are arranged in a compact cluster inside each of a pair of nuchal tentacles situated at about the first quarter of the body-length. Between the clusters of tentacular eyes lie the cerebral eyes, which are distinctly smaller and disposed in two irregular elongate groups. Marginal eyes encircle the body; anteriorly they are arranged in three or four irregular rows, but diminish gradually to a single row of widely-separated eyes along the posterior margin. There are also a few widely-scattered frontal eyes. No primordium of the reproductive system has been made out.

A second specimen, also immature, of what is probably the same species was collected at:

LOCALITY: Western Australia (on muddy bottom in 55 ft., Sulphur Rock Windmill, Channel,/Cockburn Sound (ca. 32°5'S., 115°40'E.), 16 Jan., 72.)

This specimen (AM. reg. no. W.5241) is likewise obovate, measuring 20 mm in length and 16 mm in maximum width. The pharynx is about two-thirds of the total length of the body, extending from close behind a pair of distinct nuchal tentacles to near the posterior end of the body. The distribution of the eyes is almost exactly like that of the small form described above, except that the marginal eyes behind the middle of the body are very sparse, difficult to make out, and might readily be overlooked. This difficulty in observing the posterior marginal eyes might suggest that in young specimens of this species these eyes may be seen around the entire margin of the body, but as the worms become larger so their marginal eyes tend to disappear in the posterior region of the body. If variation of this kind does generally occur in the distribution of the marginal eyes among members of the family Stylochidae, it is very important at the present time, because a number of genera and species belonging to this family have been differentiated from one another primarily on the basis of whether or not marginal eyes encircle the body. Unfortunately, little is understood of morphological variation in polyclads, as each of the majority of known species is recognized only from the description of one specimen.

Family Hoploplanidae Stummer-Traunfels, 1933

Hoploplana rosea sp. nov. Fig. 2 a-c.

LOCALITY: South Australia (living on bryozoan at 45 ft., Onkaparinga (35°9'S., 138°29'E.), 25 Feb.,72.)

MATERIAL: 1 specimen (holotype) (AM.reg.no. W. 5243)

The body is nearly discoid and measures 7 mm long and 6 mm wide. Its dorsal surface is densely covered with relatively long transparent papillae, which measure up to 0.6 mm in length in the middle region of the body and gradually become shorter towards the margins. The ground-colour of this surface is a very pale yellow, but between the papillae the surface is tinged with deep pink arising from large rhabdites lying in the epidermis, so that the dorsal surface of a specimen cleared in methyl salicylate appears to be spotted with small transparent areas (fig.2a). A colour transparency of the living worm shows the dorsal surface of the body to be pinkish, but the margins carry rectangular specks of brownish pigment. The under surface of the body is greyish.

The dorsal epithelium is rather deep between the papillae, and each cell is packed with a large pinkish rhabdite, but the ventral epidermis is without such rhabdites and lacks coloration. The papillae arise from the dorsal basement-membrane and are covered with an epithelium without rhabdites, but well provided with cilia. Each papilla is filled with a very loose parenchyma.

A pair of well-separated, blunt, nuchal tentacles are situated at about 3 mm from the anterior margin of the body. Tentacular eyes form a ring at the base of each tentacle, and cerebral eyes lie in two somewhat scattered clusters in front of the level of the tentacles, and a single eye occurs on each side of the median line between the tentacles (fig.2b).

The mouth lies centrally on the ventral surface of the body. It opens into a pharyngeal chamber containing a relatively large pharynx with four pairs of deep lateral pockets, as is usual in the genus *Hoploplana*.

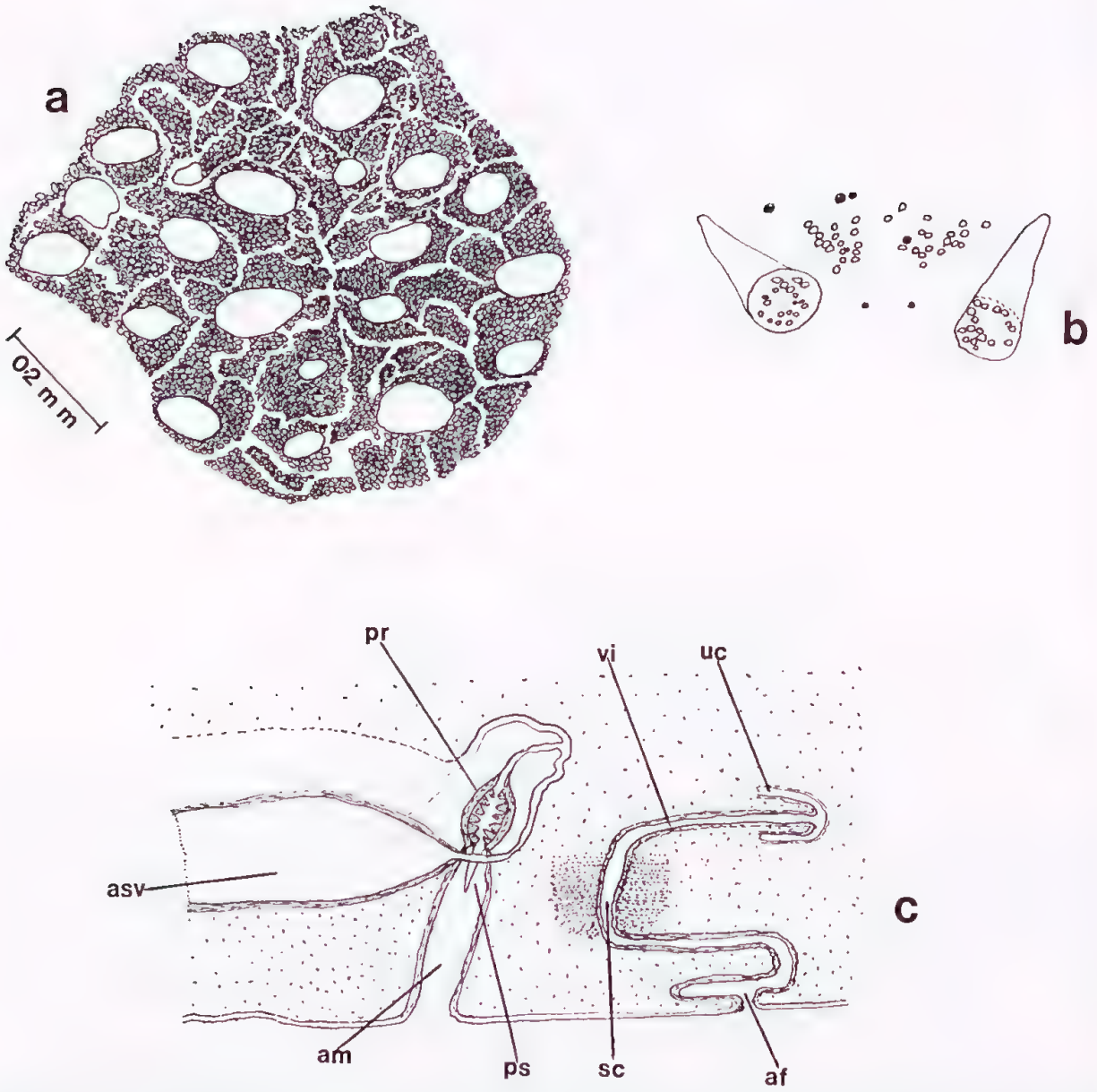

Fig. 2. *Hoploplana rosea* n. sp. (a) Distribution of pigment and papillae on dorsal surface of cleared specimen; (b) Arrangement of cerebral and tentacular eyes (dorsal view); (c) Sagittal section through copulatory complexes (diagrammatic).

Lettering on figures:
am., antrum masculinum; *af.*, antrum femininum; *asv.*, accessory seminal vesicle; *pr.*, prostatic organ; *pp.*, penis-papilla; *ps.*, penis-stylet; *psh.*, penis-sheath., *sc.*, shell-chamber; *sg.*, shell-glands; *uc.*, uterine canal; *vi.*, vagina interna; *v.s.*, vesicula seminalis.

The reproductive system is typical of the genus. The testes lie close to the ventral body wall, whereas the ovaries are placed dorsally to, or between, the intestinal branches. The vasa deferentia open into a pair of elongate muscular accessory seminal vesicles, disposed obliquely to the median line, and from each of which a narrow thin-walled sperm-duct runs inwardly, passing through the mass of "shell"-glands investing the vagina. In the median line, the sperm-ducts unite to form a short ejaculatory duct, which passes into a small pyriform prostatic organ lined with a tall glandular epithelium. Attached to the distal end of the prostatic organ, there is a straight stylet, about as long as the prostatic organ. This stylet lies in a long antrum masculinum, which has only a thin muscular wall and opens to the exterior at about 1.6 mm from the hinder margin of the body.

The female aperture is situated at about 0.24 mm behind the male pore. It leads into a shallow antrum femininum, which soon passes into a relatively long "shell"-chamber. At the junction of this chamber and the antrum, the female canal widens considerably, but the cavity is depressed dorso-ventrally. From this cavity, the "shell"-chamber forms an anteriorly-directed curve and behind the male antrum it recurves posteriorly to open into the vagina interna, which is lined with tall vacuolate cells. At the inner end of the vagina interna, the short uterine canals unite to open into it. These canals extend anteriorly only as far as the hinder level of the pharynx.

Of the papillate species of the genus *Hoploplana,* the present form resembles more closely *H. rubra* Kato, 1944, from Japan and *H. californicum* Hyman, 1953, from southern California. It differs from *H. rubra,* however, in having as many cerebral eyes as there are tentacular eyes, in having a straight penis-stylet, in not having a "cyanophilous secretion pouch" situated between the "shell"-chamber and the vagina interna, and in having a dorsal epidermis well endowed with rhabdites. From. *H. californicum,* the present species may be differentiated primarily by the absence of a thick musculature to the male antrum and by the more arcuate course of the vagina.

Hoploplana is a genus that ranges widely in the northern hemisphere and is known to extend from the tropical to temperate waters in both the Pacific and Atlantic Oceans. In the southern hemisphere it is little known, having been found hitherto only at Sao Paulo on the coast of Brazil (Marcus, 1950). A fact of ecological interest is that certain species of the genus have a tendency to live as commensals in the mantle-cavity of bivalve molluscs.

Family PLANOCERIDAE Stimpson, 1857

Paraplanocera oligoglena (Schmarda, 1859). Fig. 3 a-b.

LOCALITY: Western Australia (under coral slab in 6 ft. at Blow Holes, Quobba (24°23'S., 113°24'E.), 22 June, 72.)

MATERIAL: 2 specimens (AM. reg. no. W.5476)

One of the two early mature specimens is badly damaged. The complete specimen is somewhat discoid and measures about 15 mm in length and 12 mm in width. The body is whitish, but in the middle region between the tentacles and the female copulatory complex the dorsal surface is speckled with blackish dots, with a further layer of similar markings situated deeper in the parenchyma above the pharyngeal pocket.

These specimens bear a strong superficial resemblance to *Planocera langii* Laidlaw, 1902, from the Laccadive Islands, Indian Ocean, but both Kato (1943) and Prudhoe (1945) have independently concluded that *P. langii* is synonymous with *Paraplanocera oligoglena*. Hyman (1953), however, did not agree with this synonymy, because the ducts

Fig. 3. *Paraplanocera oligoglena*. (a) Dorsal view; (b) Arrangement of cerebral and tentacular eyes.

from the paired seminal vesicles open through an ejaculatory duct into the prostatic organ in *P. oligoglena* and not separately into the prostatic duct, as in *P. langii*. This gives rise to a controversial point, because, as Hyman says, Stummer-Traunfels (1933) redescribed the type-specimens of *P. oligoglena*, but he actually stated that the ascending ejaculatory duct opens into a funnel-shaped antechamber of the prostatic organ, which corresponds to a short ductus granulosus. If the "ductus granulosus" were to be interpreted as a prostatic duct then the difference would be merely a supposed one. The fact is that in *P. oligoglena* the ejaculatory duct usually enters the prostatic duct at its junction with the prostatic organ, but if the male complex be contracted it might therefore seem that the ejaculatory duct opened into the prostatic organ at this junction, but if the prostatic organ and its efferent duct be protracted then the ejaculatory duct would probably appear to enter the prostatic duct. Regarding the characteristic of *P. langii*, from Laidlaw's description of the male complex it is clear that he did not understand its structure fully, and it is reasonable to assume that he probably mistook the openings of the pair of accessory prostatic organs for those of the ducts running from the accessory seminal vesicles.

Having again studied the question of the synonymy of *Paraplanocera oligoglena*, the present writer does not retract his earlier opinion on this problem, and further considers *Paraplanocera fritillata* Hyman, 1959, also to be a synonym of *P. oligoglena*. This species appears to be very widely distributed in the tropical and subtropical region of the Pacific and Indian Oceans, and its occurrence in similar regions in Australian waters is probably common.

COTYLEA

Family PSEUDOCERIDAE Lang, 1884

Pseudoceros flavomarginatus Laidlaw, 1902

LOCALITY: Queensland (on reef in 25 ft., Barren I., Yeppoon (ca. 23°5'S., 150°42'E.), Dec., 72)

MATERIAL: 1 specimen (AM. reg. no. W.5431)

This specimen is oval, rounded on the anterior and posterior margins, and measures 28 mm in length and up to 16 mm in width. Dorsally the worm is smooth and velvety black, with a fairly broad whitish marginal band, about 1.5 mm wide, and which is slightly tinged with orange. The under surface of the body is ash-grey, with a distinct tinge of brown in the median region, and gradually becoming darker towards the margins of the body, where in the submarginal zones the colour is greyish black, enclosed in a light-coloured marginal band, a continuation of the dorsal band and of similar width.

The anterior margin of the body bears a deep median notch, at the base of which lies a pair of retracted tentacles that are deep black, thus obscuring the arrangement of the eyes, even when the specimen is cleared in methyl salicylate. Just behind the tentacles dorsally there is a pigment-free area, enclosing two elongate clusters of cerebral eyes which almost merge together to form a somewhat cuneate mass. As only one specimen is available no attempt has been made to decolorize it to enable the arrangement of the tentacular eyes to be observed.

Ventrally, at about 5 mm behind the anterior margin of the body, the mouth leads into the middle of the pharyngeal chamber containing a much-folded pharynx. The ventral sucker is small and situated at about 9 mm behind the mouth.

A pair of symmetrically-disposed male pores lies in the median field, at about 4 mm posteriorly to the mouth, and closely following them the female pore lies in the median line.

Laidlaw's original account is very brief, and it might be suggested that it is too inadequate for the recognition of the species, but however brief the description the present specimen fits it very well. Kato (1944) considers that the Japanese *Pseudoceros luteomarginatus* Yeri & Kaburaki, 1918, is a synonym of *P. flavomarginatus,* but at the moment there must be some doubt about this synonymy because *P. luteomarginatus* has a submarginal band of clear yellow and a marginal band of russet-brown. Nevertheless, it now seems that the range of *P. flavomarginatus* extends from the Laccadive Islands in the Indian Ocean to the Great Barrier Reef and indicates a very wide distribution in the Indo-Pacific region.

Pseudoceros gratus Kato, 1937

Eurylepta striata Schmarda, 1859, *nec Eurylepta striata* (Kelaart, 1858) Collingwood, 1876.

Pseudoceros striatus: Stummer-Traunfels, 1933, *nec P. striatus* (Kelaart, 1858) Lang, 1884.

Pseudoceros strigosus Marcus, 1950.

LOCALITY: Western Australia (under a coral slab in 4 ft. at Blow Holes, Quobba (24°23'S., 113°24'E.), 22 June, 72.)

MATERIAL: 3 specimens (AM. reg. no. W.5458)

These specimens are much distorted by curling during fixation, but it has been possible to make out the coloration and markings quite readily. The largest specimen is 20 mm in length, but is apparently immature. Dorsally, in both living and preserved specimens, the body is white and marked with three longitudinal black or brownish-black bands, a median one and a lateral pair. The wide median band commences immediately behind the cluster of cerebral eyes, but does not quite reach to the hinder end of the body. In the largest specimen, the central black band carries a median whitish streak in its anterior half, but in the smallest specimen a similar whitish streak extends the whole length of the band. This appears to indicate that as the worms become older, so the whitish streak in the median black band tends to disappear. Each lateral black band commences immediately behind the tentacular fold on the respective side and extends posteriorly to join its partner from the other side close behind the median band. Further, the entire margin of the body is bordered by a narrow black band. The ventral surface is whitish and without any markings. The tentacular folds are also darkish.

The cerebral eyes form a somewhat triangular cluster, the arrangement of which, together with the eyes in the well-developed tentacular folds, very closely resembles that depicted by Kato (1937), except that the eyes are less numerous in the present specimens, which is to be expected since they are not fully grown.

Pseudoceros gratus very closely resembles *Eurylepta striata* Schmarda, 1859, but its coloration is different, for the ground-colour of Schmarda's form is yellowish or somewhat loamy, and the bands are brownish. The difference in coloration, however, does not invalidate the conclusion of Hyman (1959) that these two species are synonymous.

In describing *Pseudoceros habroptilus* from Vanikoro Island in the Solomons, Hyman (1959) mentions only its coloration and markings and makes no observations on its other features or on its similarity with other species of *Pseudoceros,* merely stating that the "colour pattern is sufficiently distinctive." *P. habroptilus* is in fact probably indentical with *P. gratus,* but, because the original specimen is badly damaged, to be more certain further specimens from the Solomon Is. are needed for comparison with the Japanese form.

P. gratus has been recorded from Ceylon and Japan, and its occurrence in Western Australia suggests that it is widely distributed in the Indo-West Pacific region.

Pseudoceros fuscopunctatus sp. nov. Figs 4 a-c; 5 a-c.

LOCALITIES: Western Australia (under rock in silty mud in 4 ft., Dunsborough (33°36'S., 115°04'E.), 29 Nov., 71; under rock at low tide, Gantheaume, Broome (18°S., 122°E.), 22 Nov.,72.)

MATERIAL: 2 specimens (AM. reg.nos. W.5242 (holotype) (Dunsborough), W.5435 (paratype) (Broome)).

The specimen from Dunsborough (Fig. 4a) is somewhat elongate oval and measures about 18 mm in length and 8 mm in width along much of its body. The ground-colour of the dorsal surface is pearly white, with transverse languettes of black along the margins. Portions of the black coloration appear to be accumulations of diffuse pigment extending dorso-ventrally through the parenchyma. In the median field, extending from behind the tentacles to the posterior region of the body, there is a broad band of irregular brown or golden-brown spots.

The anterior marginal tentacles are well defined and carry several irregular rows of eyes ventrally along the inner or median side of each tentacle (fig. 4b). The cerebral eyes are arranged in a rounded cluster (fig. 4c) situated in the median line, immediately behind the tentacles.

The mouth is situated centrally, at about 0.5 mm behind the cerebral eye-cluster, and opens into the anterior region of the pharyngeal chamber, which contains a pharynx in the form of an elongate muscular structure measuring about 1.8 mm long and showing little evidence of the plication typical of the pseudocerid polyclads. The ventral sucker lies at about 7 mm from the anterior end of the body.

There is no indication of the presence of copulatory complexes.

In Gillett and McNeil (1959; 112) there is an excellent coloured figure (second specimen from top of plate) of this new form, to which no name was attached.

The body of the specimen from Gantheaume (fig. 5a) is elongate oval and rounded at both extremities. It is 11 mm in length and 7 mm in maximum width, which occurs at about the middle of the body. The coloration of the dorsal surface of the preserved specimen is yellowish white, with a number of blackish spots of varying size disposed in the marginal zones. The black pigment forming these spots is better seen when the specimen is cleared. It appears to occur in the parenchyma and becomes diffused into the epithelium of the dorsal and ventral walls of the body. On the other hand, a copy of a colour-transparency shows that in life the worm has almost exactly the colour and markings of the specimen from Dunsborough and is, no doubt, specifically identical with it. A pair of well-developed elongate marginal tentacles is situated anteriorly. They measure about 1.3 mm in length and contain a number of eyes, many of which lie in the basal region of each tentacle and others in the lateral regions. A compact rounded mass of small eyes lies above the cerebral organ situated close behind the tentacles.

Fig. 4. *Pseudoceros fuscopunctatus* n.sp. (a) Dorsal view; (b) tentacular eyes (ventral view); (c) Cerebral eyes (dorsal view).

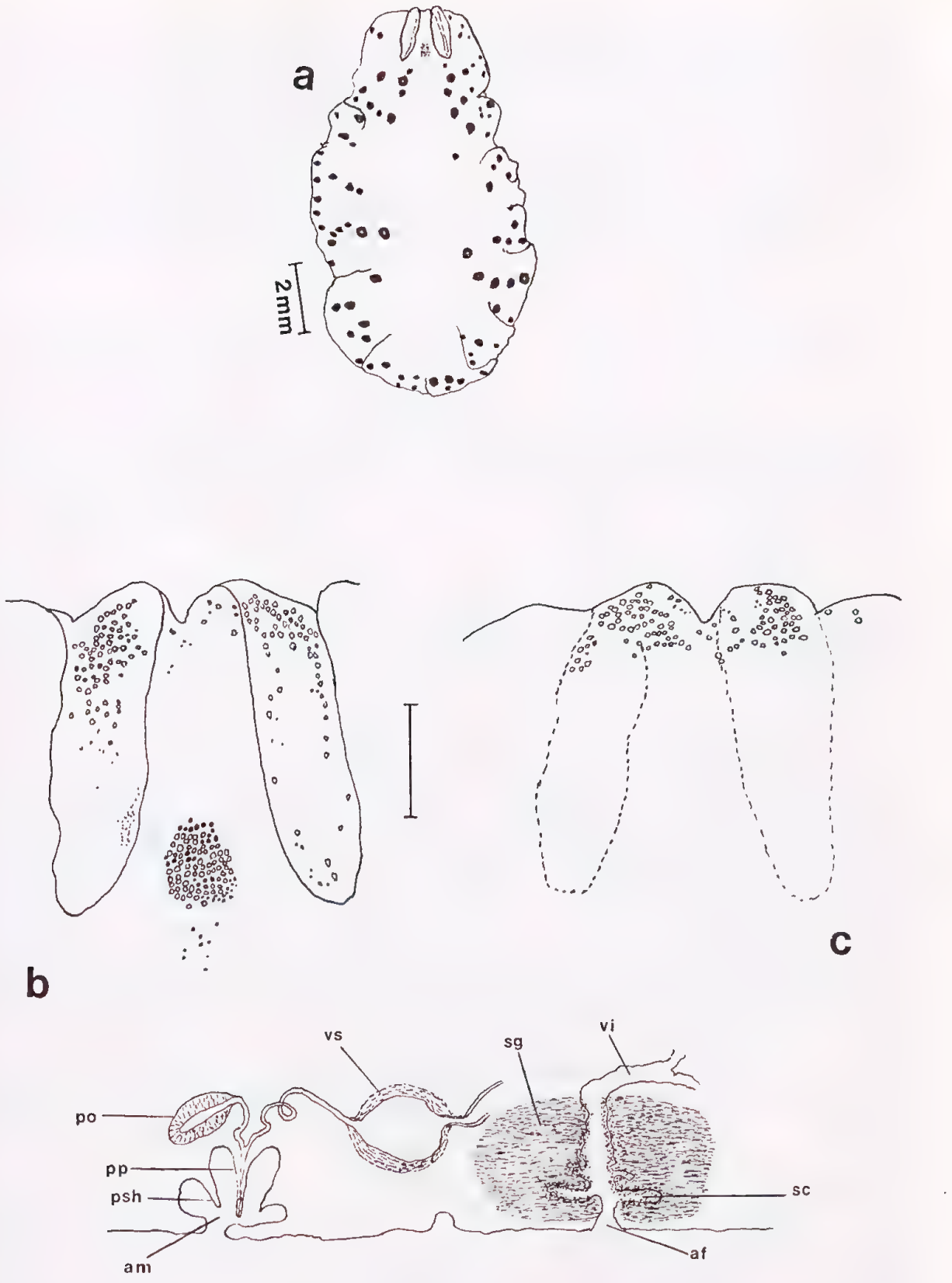

Fig. 5. *Pseudoceros fuscopunctatus* n.sp. (a) Dorsal view of cleared specimen; (b) Arrangement of cerebral and tentacular eyes (dorsal view); (c) Arrangement of tentacular eyes (ventral view).

Fig. 6c. Sagittal section through copulatory complexes (diagrammatic).

A small indistinct ventral sucker lies in the hinder half of the body. The mouth is situated at about 1.5 mm from the anterior margin of the body and opens into the middle of the pharyngeal chamber. The latter contains a small pharynx measuring about 1.2 mm in length. The intestinal branches anastomose freely to reach the periphery of the body. After opening into the pharynx, the intestinal trunk gives rise to a trio of anteriorly-directed branches, one passing along the median line dorsally to the pharynx, whilst the other two pass alongside the pharynx to unite with the median branch ventrally to the cerebral eye-cluster. At about 0.29 mm behind the mouth lies the male pore and at a similar distance behind the male pore lies the female pore. The testes and ovaries intermingle dorsally to, and between, the intestinal branches. The copulatory complexes are fully developed, and the penis-papilla is armed with a stout stylet.

Since the superficial features of this polyclad are distinctive enough for specific determination, it has not been thought necessary to section its copulatory complexes. In the cleared specimen the complexes seem to be indistinguishable from those of other species of *Pseudoceros*. Nevertheless, it is perhaps worthy of note that a small globular seminal vesicle lies close in front of the vagina. Situated antero-laterally to the seminal vesicle, there is an elongate independent prostatic organ with thick walls and a relatively narrow lumen. The length of this organ is about twice the diameter of the seminal vesicle. Beneath the distal end of the prostatic organ, lies a large globular antrum masculinum, into which projects the penis-papilla. The antrum femininum is less than half as spacious as the male antrum.

The outstanding feature of this species is the presence of laterally-disposed patches of black pigment, which extend through the parenchyma from the upper to the lower surface of the body. Other characters which may be specific are the bulbous antrum masculinum, and the short pharynx which bears a strong superficial resemblance to the euryleptid type.

It will be noted that the superficial features of these two preserved specimens are so different as to suggest that they represent two different species. In fact, for a time it was thought that they were, and only after seeing duplicate colour-transparencies of the two living specimens was it realized that they were specifically identical. The only feature in coloration in which the two preserved specimens agreed was the diffusion of black pigment through the parenchyma from the dorsal surface to the ventral surface of the body. This feature is most unusual among polyclads, but it tends to support the specific identity of these two specimens.

The preserved specimen W.5442 (fig. 4a) was, when first examined, very much like the living animal in coloration and markings, but later the ground-colour and the central markings disappeared.

Pseudoceros leptostictus Bock, 1913.

LOCALITY: Western Australia (on reef at low tide, Warroora (23°29'S., 113°48'E.), 28 June, 72)

MATERIAL: 1 specimen (AM. reg. no. W.5457).

This specimen is much contorted, but it bears a very strong resemblance to the original alcohol-preserved specimen of this species inasmuch as the dorsal surface is of a sandy yellow, but brighter yellow in the median line, becoming a reddish yellow towards the margins. The black stippling over the dorsal surface of the original specimen forms a fine network in the present specimen. Around the entire margin there is a band of quadrangular blackish markings bounded by a thin band of yellow. In a

colour-transparency of the living worm, the dorsal surface is brownish, with a narrow median band of white, from which the ground colour becomes progressively darker towards the margins of the body. A number of small whitish spots are scattered over the dorsal surface. The extreme margin of the worm is whitish and encloses a darkish band of similar width . There is a noticeable difference in the coloration of the present specimen when living and when preserved. In the preserved condition the ventral surface is whitish with a blackish margin.

It seems that *P. leptostictus* has so far been found only on the coast of Western Australia, for Bock's original specimen was taken at a depth of 72 feet, off Cape Joubert in 1911.

Pseudoceros colemani sp. nov. Fig. 6 a-c.

LOCALITY: New South Wales (on Sycozoa in 25 ft., Shiprock, Port Hacking (34°04'S., 157°08'E.), Dec., 72.)

MATERIAL: 1 mature (holotype) and 3 juvenile (paratypes) specimens (AM. reg. no. W. 5434).

The body is more or less discoid and measures about 9 mm in length and 8 mm in maximum width in the largest specimen, which is mature. Marginal tentacles are represented by a pair of distinct folds in the anterior margin. A well-developed ventral sucker is situated more or less in the middle of the body. The dorsal surface is smooth, but the ventral surface bears a series of shallow superficial ridges forming half rings in the posterior half of the body and arranged concentrically.

The coloration of the dorsal surface is dark ash-grey, owing to minute pigment granules in the epidermis, and where areas of this epidermis have been sloughed off the body is colourless, thereby giving the surface a mottled appearance. In the median field of the dorsal surface, close behind the tentacles, the colour is deeper than on the remainder of the surface, with the extreme margin of the body provided with a thin band of black, which is wider on the tentacles. Ventrally, the body is somewhat lighter in colour than the dorsal surface. In a colour-transparency of the living animal the body is obovate and shows the dorsal surface to be reddish brown, with whitish spots, and with marginal folds showing the under surface of the body to be greyish.

The cerebral eyes are disposed more or less in a triangular group, with the apex directed anteriorly, and containing 18 to 23 eyes. A pair of widely-separated eyes lies in front of the main group. The tentacular eyes are not numerous and occur only on the median side of each tentacle. These eyes do not meet in the median line between the tentacles.

A rather small pharynx appears to form a ruffle around the mouth, which is situated close behind the cerebral eye-cluster. A short distance behind the mouth lies the male pore, with the female opening somewhat nearer to the pore than to the ventral sucker.

The dorsal epithelium is rather tall, but gradually becomes less so towards the margin of the body. Ventrally, the height of the marginal epithelium is similar to that on the dorsal side, but towards the median line the epithelium gradually becomes lower. Rhabdites are numerous in the dorsal epithelium, but in the ventral epithelium they are scarce, except in the marginal areas.

Fig. 6. *Pseudoceros colemani* n.sp. (a) Ventral view: (b) Arrangement of cerebral and tentacular eyes (dorsal view).

The testes are disposed in the ventral parenchyma and are distinctly separated from the ovaries which lie dorsally to the intestinal branches. The vasa deferentia run dorsally to the ovaries from behind the ventral sucker, and extend forward to the level of the copulatory organs, where they curve towards the median line to unite and form a short ejaculatory duct. This duct opens into a bulbous seminal vesicle, from which it winds anteriorly to join with the prostatic duct at the base of the penis-papilla. Lying above the papilla is a small pyriform prostatic organ, which is only about one-half as large as the seminal vesicle. The penis-papilla is relatively large and armed with a strong straight stylet. Both the papilla and its stylet lie within a well-developed penis-pocket, which through a penis-sheath opens into a spacious male antrum.

The female complex is typical of the genus *Pseudoceros*. Its external opening leads into a relatively wide antrum femininum, which opens into a less dilated region of the vagina invested with a globular mass of "shell"-glands and represents the "shell"-chamber. From this chamber, the vagina interna is directed dorsally and posteriorly to be soon joined by the uterine canals. At this junction the vagina is terminated, and the uterine canals are directed posteriorly, but beneath the ovaries.

This form bears some resemblance to *Pseudoceros periphaeus* Bock, 1913, originally taken at Cape Joubert, W. Australia, but its main feature is, however, the presence on the ventral surface of the body of a series of shallow folds or ridges disposed in concentric semi-circles, a feature which is so far unique among species of the genus *Pseudoceros*. The animal is named *Pseudoceros colemani* in honour of Mr. Neville Coleman, who collected the material.

Acanthozoon albopunctatus sp. nov. Fig. 7.

LOCALITY: Western Australia (in 35 ft., three-mile reef, City Beach, Perth, 16 March, 72.)

MATERIAL: 1 specimen (holotype) (AM. reg. no. W.5240)

The body of this specimen is oval, but rounded at both ends, and measures about 22 mm in length and 13 mm in maximum width. Its dorsal surface is black, with a broad whitish marginal band. The area covered by black pigment bears numerous small whitish spots, each of which is enclosed in a short blunt papilla or tubercle, which is transparent and without pigment. The whitish spots appear to be short dorsal diverticula of the intestinal branches extending into the papillae. The ventral surface is ashy grey, becoming darker towards the margins, and without whitish spots or tubercles. Its margin, however, carries a whitish band similar in width to that of the upper surface. The dorsal and ventral marginal bands are separated from one another by a narrow black line on the extreme edge of the body.

The anterior margin of the body is notched between the tentacles, and 7 mm behind this notch lies the mouth. The dorsal and ventral whitish marginal bands do not appear on the tentacles. The ventral sucker is situated a little posteriorly to the middle of the body, in fact, 7 mm behind the mouth.

The specimen appears to be immature, and no indication of genital pores are visible on the ventral surface.

The feature of this species in the genus *Acanthozoon* is the deep whitish marginal band, apparent on both dorsal and ventral surfaces, but which is actually divided into two bands by a thin black line on the extreme margin of the body.

Thysanozoon aucklandicum Cheeseman, 1883.

LOCALITY: Western Australia (among rubble in 25 ft., Hall's Bank, Fremantle, 13 April, 72.)

MATERIAL: 1 specimen (AM. reg. no. W.5484)

The specimen available is in rather poor condition, for it is rolled into a tight ball, and fragments of the body-margins will break off if any attempt be made to open it out.

Fig. 7. *Acanthozoon albopunctatus* n.sp. Posterior region (dorsal view).

The dorsal surface is greyish, marbled with pale areas, and bears numerous large papillae, which are of a darker or bluish grey. The cerebral eyes are arranged in a crescentic patch, which may, however, be due to contraction of the body. Tentacular eyes have not been made out, but it is possible that the tentacular folds have broken off the body.

The present specimen is provisionally assigned to *Thysanozoon aucklandicum*, for it agrees well with a colour-variant of this species described by Cheeseman (1883).

Fig. 8. *Thysanozoon skottsbergi*. Arrangement of eyes in tentacular region (dorsal view).

Thysanozoon skottsbergi Bock, 1923. Fig. 8.

LOCALITY: Western Australia (under rock, in 4 ft., Gun Is., Hautmann Abrolhos (28°53'S., 113°52'E.), 12 July, 72 (W.5447); among rubble in 25 ft., Hall's Bank, Fremantle, 13 April, 72 (W.5482/83.)

MATERIAL: 3 specimens (AM. reg. nos. W.5447, W.5482, W.5483).

The specimen from Gun Is. is mature and measures about 25 mm in length and 17 mm in maximum width, whereas the specimens from Hall's Bank are immature and measure 14 mm long and 10 mm wide, and 10 mm long and 7 mm wide. In the smallest specimen the ventral sucker is centrally placed, but in the largest specimen it lies well behind the middle of the body. In the mature specimen the pharynx is 8 mm in length and immediately behind it lie two symmetrically-placed male pores. The female pore occurs at the tip of a prominence placed in the median line immediately behind the male pores, and about 3 mm behind this lies the ventral sucker.

According to Bock (1923), the type-specimen of this species has a ground-colour of pale yellow speckled with greenish grey. The papillae are lighter in colour. The finely-drawn papilla-points are coloured with fine blackish pigment-granules. The papillae themselves are otherwise scarcely provided with such granules. On the upper surface of the body between the papillae is to be found a layer of tiny black pigment-granules sparse towards the margins, but dense in the middle zone of the body. In this specimen, Bock states that the cerebral eyes are clearly separated into two groups which merge anteriorly. In the largest of the present specimens the cerebral eyes are also disposed in two groups, but they are so arranged as to give the impression that they form a single oval group with a median posterior cleft reaching to the middle of the cluster, as shown in fig. 8.

This species was known hitherto to occur only in sand and calcareous algae in 20 to 30 metres at Masatierra Island, one of the Juan Fernandez group off the coast of Chile. The present specimens agree so well with Bock's description of the external features of *Thysanozoon skottsbergi* that the present writer has no hesitation in assigning them to this species. The ground-colour of these specimens is tawny dorsally, and whitish and without pigment ventrally. The tawny ground-colour is punctated with grey. The papillae are lighter in colour, and the fine drawn-out papilla-tips are blackish. A colour-transparency of the largest specimen shows the ground-colour of the upper surface of the living animal is of a brownish red, speckled with whitish spots of variable size, and edged with a thin marginal band of white. The distinct papillae are lighter in colour, and their tips are much darkened with black. The marginal tentacles are also darkened with fine black granules. The cerebral eyes appear to lie in a colourles median area situated just behind the tentacles.

ACKNOWLEDGMENTS

The writer is greatly indebted to Dr. P. Hutchings for the opportunity to study and report on this collection, and to Miss Karen Handley and Mr. Neville Coleman for supplying duplicate copies of colour-transparencies of living worms.

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A Revision of the Eatoniellidae of Australia (Mollusca, Gastropoda, Littorinacea)

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SUMMARY

The 20 Recent species and 1 fossil subspecies of the Eatoniellidae in Australia are reviewed, and 13 are described as new. The shells, radulae and opercula and, in some cases, the external appearance of the head-foot, are described and the distribution and habitat of each species is given. The species fall into 2 genera, *Eatoniella* Dall (with 2 subgenera, *Eatoniella* s.s. and *Albosabula* Ponder) and *Crassitoniella* Ponder. A list of the known species of the Eatoniellidae is given (with the exception of the New Zealand species). Replacement names are provided for *Eatoniella maculosa* Ponder, 1965 and *Rissoina pellucida* Preston, 1905

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INTRODUCTION

The family Eatoniellidae was introduced by Ponder (1965) for a group of marine micro-molluscs that are abundant in New Zealand and which were previously included in the Rissoidae and Rissoinidae. The family is also known to occur in the Antarctic and Subantarctic regions, Chile, Japan, South Africa, Sri Lanka, Hawaii (an undescribed species) and Australia. The Eatoniellidae reaches its greatest numbers in New Zealand (43 Recent species) and southern Australia (18 Recent species), there being only 3 species known from tropical Australia, and only one of these appears to be widespread.

The family is characterised by a simple, usually ovate-conical or conical shell with a strongly retracted outer lip, horny operculum bearing a peg, open male and female pallial genital ducts and the aphallate condition of the male. The animal has a simple foot with 0-2 tentacles on the opercular lobe and a posterior mucous-slit in the sole. The cephalic tentacles are long, simple, tapering and lash about as the animal crawls.

Records of The Australian Museum, 1977, **Vol. 31 No. 15**, 606-658, Figures 1-14.

These animals are abundant in the lower littoral and shallow sublittoral zones, where they live mostly on algae, and a few species live on the continental shelf.

Golikov and Starobogatov (1975) have transferred the Eatoniellidae from the Littorinacea where it was placed by Ponder (1968) to the Cerithiacea (=Cerithioidea of their usage). They give no reasons for transferring the family except that it is "on the basis of Ponder's (1965, 1968) anatomical findings." In our view the presence of "oesophageal" (=buccal) pouches and an oesophageal gland, and the absence of a crystalline style and of strongly dimorphic sperm favour the placement of the Eatoniellidae with the Littorinacea.

The present revision is concerned with describing the Australian species currently in hand. Inadequate material of a number of additional species is also held but no further mention of these will be made herein. A few fossil specimens were available for examination but only one species has been included in this revision. The unidentifiable remainder are mostly single specimens in poor condition.

A key to the Recent species is given below and is based on shell features (including colour) and, in a few cases, the colour of the operculum.

MATERIAL AND METHODS

Most of the specimens used in this study were obtained from littoral or sublittoral samples washed from algae or from beneath stones. These "washings" were usually fixed in 10% neutral formalin and later preserved in 5% neutral formalin and/or dried. Other material was obtained from dredge samples. All samples were sorted beneath a stereomicroscope and the species initially separated mostly on shell characters. The radula was obtained by macerating the animal, after its removal from the shell, in concentrated, warm NaOH, and this was then washed thoroughly in distilled water. It was then mounted wet on to a piece of microscope-slide cover slip and this fixed to a scanning electron microscope (S.E.M.) stub by double-sided tape. The radula dried on to the glass with sufficient tenacity so that no additional adhesion was required. The operculum of each specimen was also mounted in the same way or directly to the double-sided tape. A shell was selected that best matched the one(s) crushed and this was mounted on the double sided tape on the same stub as the radula and operculum. In many cases more than one radula and operculum were examined from one population. The specimens were coated, usually with gold, and examined and photographed with the scanning electron microscope.

The S.E.M. stubs were given registered numbers (S.E.M. stub no.) and these are referred to in the text. All of this material, and other material referred to in the text, is housed in The Australian Museum collections unless otherwise stated.

Most of the material included in this revision was collected alive although a few species can be readily identified as "dead" shells.

ABBREVIATIONS

A.M. ..... Australian Museum, Sydney.
B.M.N.H. ..... British Museum (Natural History), London.
coll. ..... Collected by.
Coll. ..... Collection.
H.U.M. ..... Humboldt University Zoologischen Museum, E. Berlin.
N.M.V. ..... National Museum of Victoria, Melbourne.
N.S.W. ..... New South Wales.
P.M. ..... Museum National d'Histoire Naturelle, Paris.
Qld. ..... Queensland.
Q.M. ..... Queensland Museum, Brisbane.

S.A. ..... South Australia.
S.A.M. ..... South Australian Museum, Adelaide.
S.A.M.D. ..... Department of Mines, South Australia.
S.E.M. ..... Scanning Electron Microscope.
sev. ..... Several.
S.W.A. ..... South Western Australia.
Tasm. ..... Tasmania.
T.M. ..... Tasmanian Museum, Hobart.
U.S.N.M. ..... National Museum of Natural History, Smithsonian Institution, Washington, D.C.
Vic. ..... Victoria.
w ..... Used in material examined to indicate the number of "wet" (i.e. formalin preserved) specimens.
W.A. ..... Western Australia.
W.A.M. ..... Western Australian Museum, Perth.
Note: In the locality data, and sometimes elsewhere, compass points (north, south, etc.) are abbreviated to N., S., etc.

TERMINOLOGY

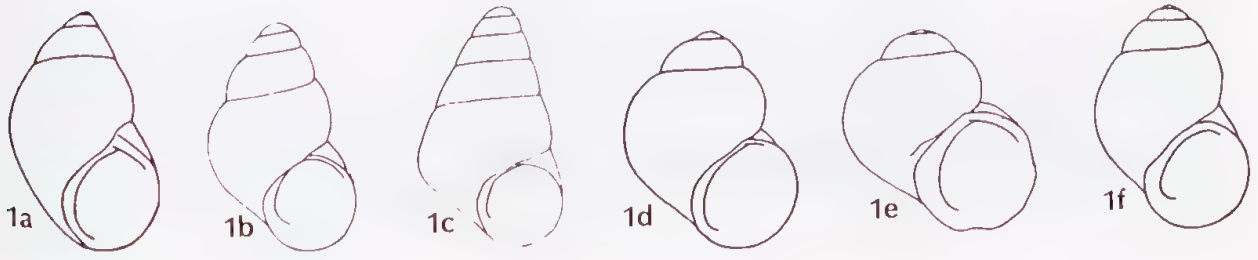
The terminology employed in the shell description follows that of Ponder and Yoo (1976) and in the description of the radula, operculum and animal it is based on Ponder (1965). Descriptions of the radula are abbreviated to a partial formula; the number of cusps for each tooth is indicated by figures (eg. 2 + 1 + 2; in this example there are 4 secondary cusps, 2 on each side of the single primary cusp [= median cusp on central teeth]). The numbers of denticles (tertiary cusps) are shown in parentheses (eg. (1) 2 + 1 + 2 (1), which indicates that there is a denticle on the outer side of the outermost secondary cusp on both sides of the tooth).

The operculum has a columellar edge (that edge facing the columella when the operculum is within the aperture), and the opposite edge is called the outer edge. It also bears a conspicuous peg arising from the nucleus of the opercular coil. Many species have an opaque muscle insertion area on the inner face which is readily distinguishable from the remainder of the translucent or transparent operculum.

KEY TO RECENT AUSTRALIAN SPECIES OF EATONIELLIDAE

This key is designed for use with material that has been collected alive, although, in some instances, it can be used with well-preserved "dead" specimens. The main problems in correctly using this key and in working with eatoniellids often lie in the subtle differences between species, and this necessitates considerable care in the initial sorting of the material. Another cause of difficulty will be the initial incorrect identification of various rissoaceans as eatoniellids.

1. (a) Shell ovate to conical (1a-c) 2
   (b) Shell depressed (1d-f) 17

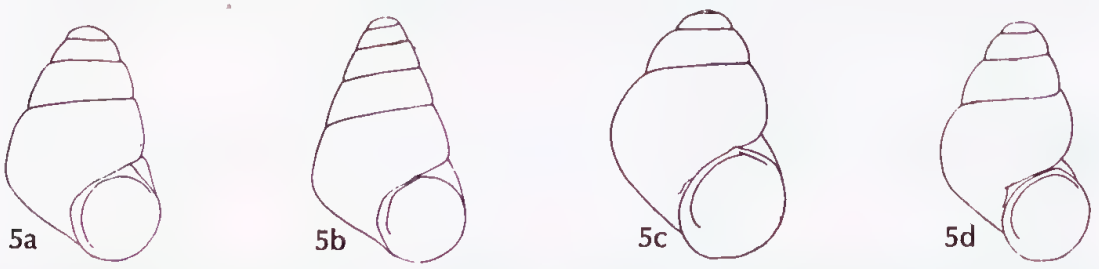


2. (a) Shell uniformly purplish-black, or with purplish-black aperture 3
   (b) Shell colourless, white, grey, yellow, orange or brown 4

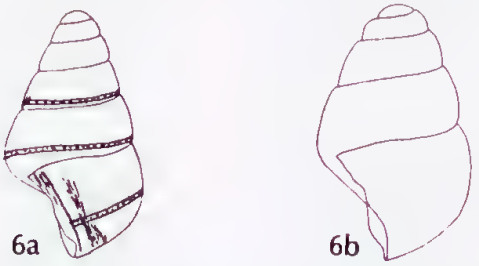
3. (a) Shell over 1.4 mm in length; operculum grey, black and yellow .....
   .....*Eatoniella (Eatoniella) melanochroma*
   (b) Shell less than 1.4 mm in length; operculum yellow .....
   .....*Eatoniella (Eatoniella) atrella*

4. (a) Shell brownish; operculum red-brown .....*Eatoniella (Eatoniella) fulva*
   (b) Shell colourless, white, yellow, grey or orange; operculum not red-brown. 5

5. (a) Shell with distinctly subangled periphery (5a, b) 6
   (b) Shell with evenly rounded periphery (5c, d) 7

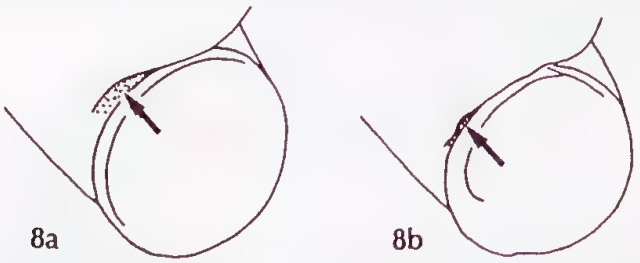


6. (a) Shell uniformly white or white with yellow or orange spiral bands; aperture with distinct varix (6a).....*Crassitoniella erratica erratica*
   (b) Shell white to orange, often with white axial streaks; aperture without distinct varix (6b).....*Crassitoniella flammea*



7. (a) Shell usually with umbilical chink, white or spotted..... 8
   (b) Shell without distinct umbilical chink, white, yellow-brown, yellow or pale grey..... 9

8. (a) Shell usually with umbilical chink, white or spotted; operculum yellow, white, grey or brown (8a)..... 10
   (b) Shell without distinct umbilical chink, yellow-brown, yellow or pale grey; operculum yellow and grey to black (8b) ...*Eatoniella (Eatoniella) galbinia*



9. (a) Shell more than 1mm in length, yellow-brown, yellow or pale grey; operculum yellow and grey to black .....*Eatoniella (Eatoniella) galbinia*
   (b) Shell less than 1mm in length, white; operculum white
   .....*Eatoniella (Eatoniella) talboti*

10. (a) Shell more or less uniformly coloured or banded 11
(b) Shell with opaque-white base and usually with rows of spots ..... *Eatoniella (Eatoniella) australiensis*

11. (a) Shell white or colourless 12
(b) Shell with 2 pink bands ..... *Eatoniella (Eatoniella) hewittae*

12. (a) Shell white, greater than 1.3mm in length 13
(b) Shell white or colourless, less than 1.3mm in length 14

13. (a) Shell white; operculum yellow ..... *Eatoniella (Eatoniella) taylorae*
(b) Shell white; operculum yellow and grey or brown ..... *Eatoniella (Eatoniella) victoriae*

14. (a) Shell solid, with evenly retracted, internally thickened outer lip 15
(b) Shell thin to fragile with bisinuate, thin outer lip 16

15. (a) Shell opaque-white ..... *Eatoniella (Albosabula) pellucida*
(b) Shell translucent, colourless ..... *Eatoniella (Eatoniella) juliae*

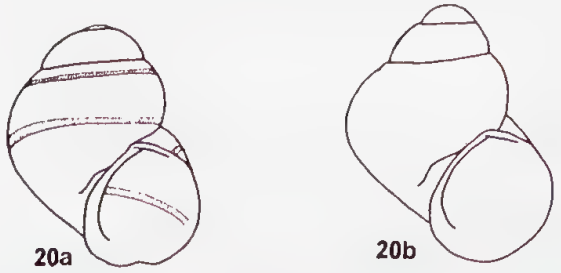
16. (a) Shell fragile, white; aperture expanded ..... *Eatoniella (Eatoniella) exigua*
(b) Shell thin, white to yellow, often with 1-2 pink bands; aperture large but not expanded ..... *Eatoniella (Eatoniella) puniceolinea*

17. (a) Shell with uniformly red-purple or pink inner lip 18
(b) Shell with white to grey inner lip 20

18. (a) Shell with pink band ..... *Eatoniella (Eatoniella) howensis*
(b) Shell (excluding aperture) more or less uniformly coloured 19

19. (a) Shell (excluding aperture) colourless ..... *Eatoniella (Eatoniella) ansonae*
(b) Shell pink to purple ..... *Eatoniella (Eatoniella) atropurpurea*

20. (a) Shell with convex spire outline (20a) 21
(b) Shell with almost straight spire outline (20b) ..... *Eatoniella (Eatoniella) shepherdi*



20a 20b

21. (a) Shell ovate, with medium spire (about equal to or greater than height of aperture), uniformly coloured; body whorl not greatly inflated 22
(b) Shell depressed-ovate, with short spire (less than height of aperture), sometimes with pink bands; body whorl markedly inflated 25

22. (a) Shell white or spotted, with umbilical chink; operculum yellow 23
(b) Shell yellow-brown, yellow or pale grey, without distinct umbilical chink; operculum yellow and grey to black ..... *Eatoniella (Eatoniella) galbinia*

23. (a) Shell with opaque white base and usually with spots ..... *Eatoniella (Eatoniella) australiensis*
(b) Shell uniformly white 24

24. (a) Shell with bisinuate outer lip, thin, less than 1.2mm in length.....
.....*Eatoniella (Eatoniella) exigua*
(b) Shell with simple outer lip, moderately solid, more than 1.4mm in length
.....*Eatoniella (Eatoniella) taylorae*

25. (a) Shell yellowish, usually with pink bands, spire moderately short (25a).....
.....*Eatoniella (Eatoniella) puniceolinea*
(b) Shell uniformly whitish, spire very short (25b).....
.....*Eatoniella (Eatoniella) depressa*

TAXONOMY

Superfamily **LITTORINACEA**

Family **Eatoniellidae** Ponder, 1965

DIAGNOSIS. Shell small to minute, depressed-ovate to conical, with D-shaped to circular aperture; outer lip excavated; surface usually smooth or (rarely) with spiral lirae; protoconch smooth, simple, paucispiral. Animal: foot simple, with 0-2 short tentacles on opercular lobes, and a posterior mucous-slit in sole; cephalic tentacles long, tapering, with eyes at outer bases; snout moderately long; sexes separate; pallial genital ducts open; male aphallate; oesophageal pouches and oesophageal gland present. Operculum horny, rather solid, often rigid, with a peg emerging from the eccentric, marginal nucleus. Radula taenioglossan with moderately large, approximately square, central teeth bearing few cusps and 1-2 basal or latero-basal processes; lateral teeth short, approximately rectangular, with few moderately large cusps; inner marginal teeth narrow, curved, with larger and fewer cusps than outer marginal teeth. Jaw a series of chitinous rods.

Genus **Eatoniella** Dall, 1876 (nom. nov. pro *Eatonia* Smith, 1875, non Hall, 1857). Type species (subsequent designation Suter, 1913): *Rissoa kerguelenensis* Smith, 1875.

DIAGNOSIS. Shell small to minute, usually rather solid, whorls weakly to moderately convex, smooth except for growth lines and, sometimes, faint spiral serration. Animal; opercular lobe with or without a single opercular tentacle on each side. Radula; central tooth with only one latero-basal process. Operculum oval to pyriform with opaque muscle-insertion area extensive to very narrow; peg strong, curved, often grooved, set at moderate angle to surface of rest of operculum; columellar margin flat to convex, never strongly convex.

REMARKS. Two subgenera are here recognised for the Australian species, *Eatoniella* s.s. and *Albosabula* Ponder.

Subgenus **Eatoniella** s.s.

Synonyms

Dardania Hutton, 1882:147, non Stål, 1866.
Dardanula Iredale, 1915:453 (nom. nov. pro *Dardania* Hutton, 1882)

Type species (monotypy): *Dardania olivacea* Hutton, 1882.

Cerostraca Oliver, 1915:521.
Type species (original designation): *C. iredalei* Oliver, 1915.

Abscindostoma Ponder, 1965:55.
Type species (original designation): *Rissoina olivacea* var. *lutea* Suter, 1908.

Albitoniella Ponder, 1965:59.
Type species (original designation): *Dardanula pallida* Powell, 1937.

Dardaniopsis Ponder, 1965:69.
Type species (original designation): *Eatoniella (Dardaniopsis) notalabia* Ponder, 1965.

DIAGNOSIS. Shell, less than 4 mm in length. Radula with each central tooth having a straight to slightly convex basal margin between heavy latero-basal projections.

REMARKS. Ponder (1965) recognised a number of subgenera of *Eatoniella* which, while being distinctive groups within the New Zealand fauna, are not clearly defined amongst the Australian species dealt with in this revision. A simplification of the existing taxonomy is required and for this reason the names listed in the synonymy above are here considered to be synonyms of *Eatoniella*.

Eatoniella (Eatoniella) ansonae sp. nov. Figs 1a, b; 5a-f.

SHELL. minute, transparent, colourless, with purplish-pink inner lip and umbilical area. Protoconch of 1½ colourless whorls; teleoconch of 2½ moderately convex whorls. Aperture simple; inner lip broad, outer edge strongly concave, abapical portion considerably separated from base; outer lip evenly retracted. Umbilical chink small, a minute umbilicus sometimes present (figs 1a, b; 5a, b).

Dimensions	Length	Diameter
Holotype	1.10 mm	0.77 mm
Paratypes	1.04	0.70
	1.15	0.74
Figured specimens (S.E.M.) (Paratypes).	1.16	0.72
	1.02	-

OPERCULUM: typical, pale yellow, opaque; muscle insertion area spread over all surface except below peg (figs 5c, d).

RADULA: central (1) 2 + 1 + 2 (1) , lateral 2 + 1 + 2, inner marginal 2 + 1 + 1 (1), outer marginal (about 6) (one radula has a freak bifid median cusp on each central tooth) (figs 5e, f).

Opercula and radulae observed from the type locality.

ANIMAL: unpigmented except for some specimens showing some blackish pigmentation on the visceral mass which is visible through the shell (preserved material).

TYPES. Holotype A.M. (C. 102236). Paratypes (20/3w) A.M. (C. 102237), 3 W.A.M. (WAM 403-76), 2 shells, 2 opercula and 4 radulae on S.E.M. stub no. 129.

TYPE LOCALITY. Off Dunsborough, S.W.A., on *Cymodocea*, 1-2m, 24 Dec. 1971, coll. W. F. Ponder.

DISTRIBUTION AND HABITAT. Known only from the type locality (fig. 11).

REMARKS. This species is very similar to *E. (E.) atropurpurea* (Frauenfeld) which also occurs in south Western Australia although it was not collected with *E. (E.) ansonae* at the type locality. The two species both have a purplish-pink inner lip but in *E. (E.) ansonae* the remainder of the shell is colourless, whereas it is pink or purplish in *E. (E.) atropurpurea*. In addition, *E. (E.) ansonae* has a relatively taller spire than most specimens of *E. (E.) atropurpurea*. In all other respects the two species seem to be almost identical and, although it is possible that *E. (E.) ansonae* may prove to be a colourless form of *E. (E.) atropurpurea*, the complete lack of any similar colour variety throughout the range of *E. (E.) atropurpurea* suggests otherwise.

This species is named for Mrs. W. Anson of Western Australia who has kindly made much material available for study.

Eatoniella (Eatoniella) atrella sp. nov. Figs 3e, f; 9n-p.

SHELL: minute, solid, ovate-conical, black or purple-black. Protoconch of 1½ whorls, dark grey to black; teleoconch of 2-2½ weakly convex whorls, spire of moderate length, about equal in length to, or slightly greater than, length of aperture. Apertural lips slightly thickened, edge of inner lip distinctly concave, sharply raised from base abapically; outer lip evenly retracted. Umbilical chink minute or absent, non- umbilicate. Colour black to dark grey, purplish-black or pinkish-grey; outer lip with black inner rim, remainder of lip slightly paler; inner lip frequently black (figs 3e, f; 9n, o).

Dimensions	Length	Diameter
Holotype	1.23 mm	0.76 mm
Paratypes	1.12	0.72
	1.28	0.77
Figured specimens (S.E.M.) (Paratypes).	1.33	0.84
	1.18	-

OPERCULUM: opaque, (except below peg) black central area with some yellow or brown coloration.

RADULA: typical. central (1) 2 + 1 + 2 (1), lateral (1) 2 + 1 + 2, inner marginal 4 + 1 + 1, outer marginal 5 + 1 (fig. 9p).

Opercula and radulae observed from the type locality (S.E.M. stub no. 238).

ANIMAL: head-foot with black pigmentation over most of dorsal surface, white ventrally except for black edges of opercular lobes; no opercular tentacles (Eaglehawk Neck, S. Tasm.)

TYPES. Holotype A.M. (C. 102238). Paratypes (52) A.M. (C. 102239, C. 102531), 3 T.M. (E9240), 3 N.M.V. (F30004), 4 shells, 2 opercula and 3 radulae on S.E.M. stub nos. 238, 265.

TYPE LOCALITY. N. side of Black Head, Nadgee, N.S.W., on coralline algae (C. 102239) and large brown algae (C. 102531) on exposed rocks, 8 Jan. 1970, coll. W. F. Ponder & P. H. Colman.

ADDITIONAL MATERIAL EXAMINED. *S. Tasm.:* Ansons Bay, 28 Dec. 1966, coll. A. Dartnall (18) (T.M.). N. end of Pirates Bay, Eaglehawk Neck, on large brown algae, mid-shore, 2 Apr. 1970, coll W. F. Ponder (4). Pirates Bay, Eaglehawk Neck, on coralline algae (2); under stone, low tide (1), coll. W. F. Ponder. Eaglehawk Neck, 3 June 1967, coll. A. Dartnall (2) (T.M.). Fortescue Bay, E. side of Tasman Peninsula, on algae, littoral, 15 Dec. 1968, coll. A. Dartnall (4). Wedge Bay, S. Tasm., 13 m, J. Voorwinde Coll. (1). *E. Vic.:* Bastion Pt., S. tip of Mallacoota, intertidal, 19 Feb. 1973, coll. P. Hutchings (4). Red Bluff,

near Lake Tyers, E. of Lakes Entrance, on small red algae, on small exposed rocky point, 11 Jan. 1970, coll. W. F. Ponder & P. H. Colman (8/4w).

DISTRIBUTION AND HABITAT. On exposed shores, mostly on algae, in S. Tasm., southern N.S.W. and E. Vic. (fig. 12).

REMARKS. This species is very similar to *E. (E.) melanochroma* (Tate) and could be regarded as a minute form of that species except that it has a somewhat different geographical distribution, occurring in eastern Victoria where *E. (E.) melanochroma* does not appear to be found, and does not occur along the rest of the southern coast of Australia where *E. (E.) melanochroma* is prolific. It is sympatric with *E. (E.) melanochroma* in southern Tasmania, Bass Strait and in the extreme S. of N.S.W.

The new species can only be distinguished from *E. (E.) melanochroma* by its much smaller size and lack of opercular tentacles. It is similar to *E. (E.) atropurpurea* in size and is sympatric with it but can be distinguished by its taller spire, the lack of any pink or pinkish-purple coloration, the slightly different radula and the darkly pigmented operculum.

Eatoniella (Eatoniella) atropurpurea (Frauenfeld, 1867). Figs 1c-i; 5g-k.

Setia atropurpurea Frauenfeld, 1867:13, pl. 2, fig. 21; Angas, 1877:187.

Rissoa atropurpurea. — Weinkauff, 1885:186, pl. 24, f. 15, 16; Pritchard & Gatliff, 1902:105; Kesteven, 1902:206.

Rissoia (Microsetia) atropurpurea, — Tryon, 1887:355, pl. 71, fig. 1.

Rissoia (Setia) atropurpurea. — Tate, 1899:234.

Notosetia atropurpurea. — Hedley, 1918:M54; Cotton, 1944:304; Laseron, 1950:281, fig. 77.

Notosetia purpureostoma May, 1919:63, pl. 16, fig. 18; May, 1921:53; May, 1923, pl. 25, fig. 4; Cotton, 1944:304.

Notosetia fusca Laseron, 1950:280, fig. 74.

Notosetia aethiopia Laseron, 1950:280, fig. 75.

Eatoniella (Dardanula) minutocrassa Ponder, 1965:84, pl. 6, figs 13-15.

SHELL: minute, solid, short spired, semi-opaque to opaque, dark purplish-grey to grey, with large body whorl and aperture, non-umbilicate or narrowly umbilicate. Protoconch of 1½-2 colourless whorls; teleoconch of about 2 moderately to strongly convex whorls; spire outlines lightly convex. Aperture with inner lip broad, distinctly concave on its outer edge; outer lip evenly retracted. Umbilical chink distinct to absent and occasionally a very narrow umbilicus present. Colour greyish-purple when fresh, purplish-pink when dead, inner lip sometimes bright pinkish-purple; edge of outer lip darker than surrounding shell (figs 1c-i; 5g, i, j).

Dimensions	Length	Diameter	
Syntype	1.1 mm	0.75 mm	(from original description)
Holotype of *Notosetia purpureostoma*	1.0	0.8	(from original description)
Figured paratype of *Notosetia purpureostoma*	1.00	0.67	

Lectotype of			
Notosetia fusca	0.90	0.68	
Notosetia aethiopia	1.16	0.83	
Holotype of			
Eatoniella minutocrassa	0.93	0.60	(from original description)
Figured specimens			
(Forster, N.S.W.)	1.02	0.70	
(Nambucca Heads, N.S.W.)	0.86	-	
(N. Stradbroke Is., Qld)	0.80	064	

OPERCULUM: uniform pale yellow in colour, opaque, muscle insertion area over all surface above peg; internal ridge just inside columellar edge (fig. 5h).

RADULA: typical. central (1) 1-2+ 1 +2-1 (1), lateral 2 +1 +2 (1), inner marginal 3 +1 +1, outer marginal (about 8); most teeth long and sharp, primary cusp of central tooth not particularly broad (fig. 5k).

Opercula and radulae observed from Forster, N.S.W. (S.E.M. stub no. 104) and North Stradbroke Is., Qld (S.E.M. stub no. 190).

ANIMAL: unpigmented, translucent white head-foot, visceral mass black to unpigmented; no opercular tentacles (Sydney).

TYPES. Syntypes. Bondi (30+), "Botany Bay" (9), "Sidney"(=Sydney) (2), Botany Bay, ex Mohrenstern (3), Bondi, ex Mohrenstern (many), all Naturhistorisches Museum, Vienna. *N. purpureostoma.* Holotype lost from T.M., paratype in A.M. (C. 45967) and in S.A.M. *N. fusca.* Lectotype (here chosen) A.M. (C. 102535) and 9 paralectotypes (C. 102536). *N. aethiopia.* Lectotype (here chosen) A.M. (C. 102537) and 36 paralectotypes (C. 102538). *E. (D). minutocrassa.* Holotype and paratypes Auckland Institute and Museum, paratypes N.Z. Geological Survey, Canterbury Museum, Christchurch, and National Museum of New Zealand.

TYPE LOCALITIES. *S. atropurpurea.* See above. All Sydney area, N.S.W. *N. purpureostoma.* Penguin, N. Tasm., in shell sand. *N. fusca.* North Harbour, Sydney, N.S.W., on algae. *N. aethiopia.* North Harbour, Sydney, N.S.W., amongst *Galeolaria* tubes. *E. (D.) minutocrassa.* Goat Island Bay, Leigh, New Zealand, in *Corallina.*

ADDITIONAL MATERIAL EXAMINED. *S. Qld:* Noosa Heads (4). Caloundra (2). *N. Stradbroke Is.;* Shag Rock, on algae, 4-9m (9/10); Wreck 4.8 km off Amity Pt., on algae, 0-4m (10); S. end of Flat Rock, on algae, 21-27m (2); Off Flat Rock, on algae, 24-30m (6/3w); N.W. side of Pt. Lookout, on short red algae, low tide, S.E.M. stub no. 190 (55/50w). Moreton Bay (9). *N.S.W.:* Ballina, on algae (3). S.W. of Solitary Is., 15m (14). Nambucca Heads, on algae, low tide, S.E.M. stub no. 96 (40/32w). S. side of Fish Rock, 3km E. of Smoky Cape, on algae, 18m (1). Off Crowdy Head, 91m (3). Forster, on algae, low tide (4/3w); on coralline algae, on boulder beach, S.E.M. stub no. 104 (20/60w). Fingal Bay, Port Stephens (65). Off Patonga Beach, Broken Bay (1). *Sydney:* Collaroy Beach (23); N.E. end of Long Reef, Collaroy, on algae, low tide (10), on *Galeolaria,* low tide (7/8w); Long Reef, Collaroy, on algae, low tide (3), on short brown algae, low tide (1w), on *Galeolaria,* low tide (3w); North Harbour (10); Fairlight (5), on coralline algae, low tide (1), on short algae, low tide (5w); Wyargine Pt., Middle Harbour, on small algae (29); The Spit, Middle Harbour (3); Balmoral, on coralline and small red algae (4w), 11-15m (1); Off Chinamans Beach, Middle Harbour (28); Bottle & Glass Rocks (40); Sydney Harbour, 2 lots (40); Sow and Pigs Reef (16), 11-16m (30), 9m, 3 lots (40); Watsons Bay, 7m (1); Little Coogee Bay, 6 lots (75); Ocean Beach, Cronulla (1); Werri Beach (14). Honeymoon Beach, Jervis Bay,

under stones, low tide (8/5w). Ulladulla (3). S. side of Ulladulla, on small brown algae, low tide (5); on coralline algae, low tide (5); on medium brown algae, low tide (1). Wimbie Beach, Batemans Bay, on exposed rocks, low tide, on coralline algae (11); on large brown algae (6); under stones (27). Bitangabee, N. side of Green Cape, on coralline algae in sheltered pool, high exposure (11). Green Cape, Disaster Bay, under stones, 15m (17). S. side of Green Cape, on algae, vertical rock faces, 16m (2); on coralline and red algae, low to mid tide (1); on coralline algae, 10m (16). *N. Tasm.:* Bass Strait; Deal Is., on algae, 6m (8); Murray Pass., Deal Is., on algae, 2 lots, 30-50m (14/5w); Little Squally Cove, Deal Is., on algae, 10-30m (2); East Cove, Deal Is., 6-15m (7). Just W. of Cape Barren Is., 34m (1) (T.M). Boat Harbour, on coralline algae in pools (1). *E. Tasm.:* S. of Cape Lodi, 28m (7). Green Cape, Maria Is., on algae, 6m (4). *S. Tasm.;* Pirates Bay, Eaglehawk Neck, low tide, under stones (13), on *Caulerpa* (1), on coralline algae (4), on brown algae (1w). Primrose Pt., E. side of Frederick Henry Bay, on coralline algae, low tide (21). Off Fluted Cape, Bruny Is., on algae, 7-10m (10). Nubeena, Wedge Bay, 7m (1). *Vic.:* E.S.E. side of Gabo Is., on algae, 28m (15/3w). Monumental Bay, Gabo Is., on algae, 15-18m (6). Gabo Is., 26m (1). Bastion Pt., S. tip of Mallacoota, intertidal (7). Pt. Hicks, Cape Everard, *Phyllospora* holdfast (2). Red Bluff, near Lake Tyers, E. of Lakes Entrance, on small red algae (5/3w). Western Port (sev) (N.M.V.). Pt. Lonsdale, on coralline algae in pools (2), under stones, low tide (1). Port Fairy, on short algae, mid-tide (1), on coralline algae (3). *S.A.:* Off Middle Pt., Cape Northumberland, on red algae, 38m (3), on algae, 13m (3). Tumby Bay (25). Waldegrave Is., on algae, 1m (3). West Is., Nuyts Archipelago, 'kelp' holdfasts, 0-12m (2). *S.W.A.:* Mississippi Bay, on algae, 0-2m (52). Cape Naturaliste (11). *W.A.:* W. side Carnac Is., off Fremantle, on algae, 4-8m (13/8w). S.W. end of Garden Is., off Fremantle, on algae (1). Protected reef off North Pt., Rottnest Is., on coralline algae (1).

DISTRIBUTION AND HABITAT. Southern Qld, S. to Tasm. and W. to mid W.A. Abundant on algae, under stones, in crevices, amongst *Galeolaria* etc. in the intertidal zone in N.S.W, and also found on algae in the sublittoral. Less common in the southern and western parts of its range (fig. 13). Also found throughout New Zealand and the Chatham Islands (Ponder, 1965).

REMARKS. This species is rather variable both in shape and height of the spire (cf. figs 5g, j) and in the intensity of coloration. Paratype specimens of *Notosetia purpureostoma* have been examined (the holotype being lost) and agree exactly with N.S.W. material of *E. (E.) atropurpurea*. Some Tasmanian specimens do, however, reach a slightly larger size than the mainland populations. New Zealand specimens agree with Australian material very closely and no reasons for maintaining separate species identity can be found. Laseron's two species names *fusca* and *aethiopia* are based on specimens which are encompassed within the range of variation of *E. (E.) atropurpurea* in the Sydney area, the former being a small variety and the latter a large variety.

The species is easily recognised by its minute size, generally uniformly dark-coloured, rather solid shell which has a pinkish or purplish, rather heavy inner lip and short spire. It is very abundant in N.S.W. in the middle to lower intertidal zone where it is found mainly on algae and amongst *Galeolaria* tubes.

This species is one of a group of apparently closely related species which includes *E. (E.) ansonae* nov., *E. (E.) howensis* nov., *E. (E.) talboti* nov., and *E. (E.) shepherdi* nov. *E. (E.) atropurpurea* differs from all of these species in its uniform purple to pink coloration and it is larger than *E. (E.) howensis* and is usually smaller than *E. (E.) shepherdi*.

Eatoniella (Eatoniella) australiensis (Thiele, 1930). Figs 2i-k; 7j-l.

Cingula (Pseudosetia) australiensis Thiele, 1930:570, fig. 5.

Lucidestea maculosa Laseron, 1956:450, fig. 172.

SHELL: minute, ovate-conical, rather thin, translucent, very pale yellowish or dirty white, with 2 spiral rows of red-brown and dense-white spots. Protoconch of 1½ whorls; teleoconch of about 2½ weak to moderately convex whorls; spire of moderate height, although somewhat variable, outlines slightly convex. Aperture rather large, inner lip very narrow, separated from parietal area by a narrow groove; outer lip usually evenly retracted. Umbilical chink small, distinct, umbilicus very narrow or absent. Colour translucent pale yellowish-brown to dirty white with a row of spots at periphery and abapical to suture; spots chevron-shaped to rectangular and made up of smaller red-brown series alternating with dense white series; peripheral row of red-brown spots often double, lower on adapical part of base; occasional specimens with no spots or 1-2 pale purplish bands in place of the rows of spots; columellar-umbilical region dense white (figs 2i-k; 7j, l).

Dimensions	Length	Diameter	
Holotype	1.5 mm	1.0 mm	(from original description)
Holotype of *Lucidestea maculosa*	1.27	0.80	
Figured specimens (S.E.M.)			
(Garden Is., W.A.)	1.54	1.03	
(Exmouth, W.A.)	1.20	0.70	

OPERCULUM: opaque pale yellowish-white, muscle insertion area over most of surface; typical in structure with very weak ridge just inside margin of columellar edge (fig. 7k).

RADULA: central (1) 2 + 1 + 2 (1), lateral (1) * 2 + 1 + 2 (1), inner marginal 3 + 1 + 1, outer marginal (about 7). (*denticle only in Shark Bay specimen).

Opercula and radulae observed from Exmouth, W.A. (S.E.M. stub no. 98) and Garden Is., W.A. (S.E.M. stub no. 136).

ANIMAL: head and sides of foot (including dorsal side of opercular lobes) pale to dark brownish, ventral snout and sole white; no tentacles on opercular lobes (Lizard Is., Qld).

TYPES. Holotype, H.U.M. (67446). *Lucidestea maculosa*. Holotype A.M. (C. 102532), paratypes (10) A.M. (C. 102240).

TYPE LOCALITY. *C. australiensis*. Cockburn Sound, W.A., 15-18m (Michaelsen and Hartmeyer stn 48). *L. maculosa*. Lindeman Is., Qld, on algae.

ADDITIONAL MATERIAL EXAMINED. *Papua New Guinea:* Port Moresby (1). *New Caledonia:* Croissant Reef, off Noumea, coral rubble and algae, 0-1m (1). W. side of Ile Signal, off Noumea, on algae, 0-2m, on sandy and dead coral bottom (1). *Qld:* Lizard Is. (sev). Headland between Kings and Queens Beaches, Bowen (15). Lindeman Is., on algae, 3 lots (11). Curtis Is., off Gladstone (4). Facing Is. (8). *S.W.A.:* South Cowaramup (5). *W.A.:* Pt. Peron, S. of Fremantle, 4m (8). W. side Carnac Is., off Fremantle, on algae, low tide (4). S.W. end of Garden Is., off Fremantle, in shell sand (7); on algae, S.E.M. stub no. 136 (36/22w). Triggs, near Perth, on brown and red algae, 0-2m (4). Cottesloe Beach, 9km W. of Perth, on calcareous algae, 0.5m (4). W. end of Thomson Bay, Rottnest Is., on algae, 0-2m (1). W. end reef, Rottnest Is, on *Lithothamnion* on intertidal reef edge (12). Protected reef off North Pt., Rottnest Is., on coralline algae (15). Green River mouth (sev). Port Denison, 65km S. of Geraldton, on algae, 0-2m (2). Horrocks Beach, N. of Geraldton, on algae (9/6w). Denham, Shark Bay, on short algae, below low tide, on flat

4-8km out of township (4/2w). 16km N. of Denham, Shark Bay (5). E. side of Exmouth, on algae, low tide, S.E.M. stub no. 98 (10/6w). Turtle Beach, W. side of N.W. Cape (24). 27km S. of Exmouth, on brown algae (sev). Just S. of wreck of S.S. "Mildura", N.W. Cape, on limestone reef platform, 0-2m (20/14w). Warroora, S. of N.W. Cape, on green algae, low tide (16). Archer Is., off Onslow, on short brown algae, 1-2m (1).

DISTRIBUTION AND HABITAT. Papua New Guinea, New Caledonia, Qld and W.A. on algae in the intertidal and sublittoral (fig. 11).

REMARKS. This species is easily distinguished by its colour pattern. There is some variation in size, outline (cf. figs 7j, l) and in the details of the colour pattern, the spiral rows of dots being variable in form and intensity and occasionally are virtually absent. It does not appear to be closely related to any other known species.

The holotype is somewhat unusual in having a weakly bisinuate outer lip. The peripheral row of white spots noted by Thiele in his description and shown in his figure have faded so that they appear to be almost absent.

Eatoniella maculosa Ponder, 1965 from New Zealand is a secondary homonym of *Lucidestea maculosa* even though the latter species name is in synonymy. We therefore provide the replacement name *Eatoniella (Eatoniella) notata* nom. nov. for *E. maculosa* Ponder, 1965, non *E. maculosa* (Laseron, 1956).

Eatoniella (Eatoniella) depressa sp. nov. Figs 1l, m;6a-c.

SHELL: minute, with depressed spire, non-umbilicate or narrowly umbilicate, with relatively very large body whorl and aperture, yellowish-white, semi-translucent. Protoconch of 1½ whorls; teleoconch of about 1½ convex whorls, the last making up majority of the shell; spire outlines convex. Inner lip with a concave outer edge; outer lip strongly retracted, frequently weakly bisinuate, Umbilicus, when present, narrow, rather indistinct. Colour translucent yellowish or greyish-white (figs 1l, m; 6a, b).

Dimensions	Length	Diameter
Holotype	1.04 mm	0.96 mm
Paratypes	1.00	0.86
	0.98	0.85
Figured specimens (S.E.M.) (Paratypes)	1.04	0.94
	1.00	-

OPERCULUM: typical, mostly transparent pale yellowish; opercular lobes when pigmented show through as black edge to operculum; a very weak ridge immediately inside columellar edge; muscle insertion area pale yellowish-white, occupying about 1/3 of area immediately inside columellar edge (fig. 6c).

RADULA: typical, central (1) 2 + 1 + 2 (1), lateral 2 + 1 + 2 (1), inner marginal 2 + 1 (1), outer marginal (about 7); primary cusps of central and inner marginal teeth rather broad and blunt.

Opercula and radulae observed from the type locality and Point Grey, Lorne, Vic. (S.E.M. stub no. 272).

ANIMAL: head-foot translucent white, often with some grey to black pigment dorsally and on opercular lobes; visceral mass brown with variable amounts of black pigment and is easily seen through shell but sometimes completely black although

usually pigment in streaks (mostly axial) on body whorl and more uniform on spire. No opercular tentacles (Eaglehawk Neck, S. Tasmania).

TYPES. Holotype A.M.(C.102241). Paratypes (51) A.M. (C.102242), 3 T.M. (E9241), 3 N.M.V. (F30005), 3 S.A.M. (D. 15252), 2 shells, 2 opercula, 3 radulae on S. E.M. stub no. 99.

TYPE LOCALITY. Moonlight Beach, W. of Cape Otway, Vic., on algae on rock platform, 11 Mar. 1973, coll. Marine Study Group.

ADDITIONAL MATERIAL EXAMINED. *N.S.W.:* On exposed side of Wimbie Beach, Batemans Bay, on coralline algae, on fairly exposed rocks, 6 Jan. 1970, coll. W. F. Ponder and P. H. Colman (5). Bitangabee, N. side of Green Cape, on coralline algae in sheltered pool, 13 Feb. 1973, coll. W. F. Ponder (15). S. end of Green Cape, N.S.W., on algae, exposed coast, 2-4m, 13 Feb. 1973., coll. W. F. Ponder (6). S. side of Green Cape, on coralline algae, 10m, 13 Feb. 1973, coll. P. Hutchings (4). N. side of Black Head, Nadgee, on large brown algae, on exposed rocks, 8 Jan. 1970, coll. W. F. Ponder and P. H. Colman (7). *N. Tasm.:* East Cove, Deal Is., Bass Strait, 6-15m, 3-10 May 1974, coll. S. A. Shepherd (1). Boat Harbour, on brown algae, 19 Mar. 1975, coll. W. F. Ponder and R. Kershaw (4). *S. Tasm.:* N. end of Pirates Bay, Eaglehawk Neck, on large brown algae, low tide, 2 Apr. 1970, coll. W. F. Ponder (11). Pirates Bay, Eaglehawk Neck, under stones, low tide, 2 Apr. 1970, coll. W. F. Ponder (2). S.E. Pirates Bay, Eaglehawk Neck, on brown algae, 31 Mar. 1970, coll. W. F. Ponder (18). *Vic.:* Bastion Pt., S. tip of Mallocoota, intertidal, 19 Feb. 1973, coll. P. Hutchings (12). Western Port, Gatliff Coll. (sev) (N.M.V.). Honeysuckle Pt., Shoreham, on rocks and algae, 23 Apr. 1973, pres. N.M.V. (5). Shoreham, Gatliff Coll. (sev) (N.M.V.). Portsea, Vic., Gatliff Coll. (sev) (N.M.V.). Pt. Lonsdale, on coralline algae in pools (5), under stones in pools (2), on large brown algae (2), on short algae, exposed edge of platform (20), 22 Mar. 1975, coll. W. F. Ponder and R. Burn. Anglesea, in sand, coll. T. S. Hall, Gatliff Coll. (1), (N.M.V.). Pt. Grey, Lorne, on exposed brown algae, 23 Mar. 1975, coll. W. F. Ponder and R. Burn, S.E.M. stub no. 272 (40). Port Fairy, 4km W. of town, 2 lots, on brown algae (1), on coralline algae (6), 19 Aug. 1973, coll. W. F. Ponder and R. Burn. *S.A.:* Tumby Bay, in shell sand, coll. J. Thompson, 2 lots (4). Waldegrave Is., on algae, 1m, 25 Oct. 1973, coll. S.A. Shepherd (3). Near Salmon Pt., Elliston Bay, on *Cystophora,* 1m, Oct. 1973, coll. S. A. Shepherd (3). *S.W.A.:* Mississippi Bay, 48km E. of Esperance, on algae, on sheltered side of west head of bay, 0-2m, 6 Feb. 1972, coll. W. F. Ponder (4).

DISTRIBUTION AND HABITAT. Southern N.S.W., Tasm. and the S. coast to S.W.A. Usually on exposed shores on algae (fig. 11).

REMARKS. This species is distinctive with its very low spire and black visceral mass. It is somewhat similar to species of *Skenella* Martens and Pfeffer, 1886, in general form, although not so depressed, but has an operculum typical of the genus *Eatoniella*. *E. (E.) depressa* does not appear to be closely allied to any other described species of *Eatoniella*.

Specimens of this species in the N.M.V. (Gatliff Coll.) are identified as *Cirsonella translucida* (May), a much larger species of uncertain affinities and certainly not an eatoniellid.

Eatoniella (Eatoniella) exigua sp. nov. Figs 2c, d; 6k-n.

SHELL: minute, ovate, translucent-white, thin, with rather swollen body whorl and large aperture. Protoconch of 1¾ colourless whorls; teleoconch of about 2 convex whorls; spire outlines moderately convex. Aperture large; inner lip narrow, strongly concave on its outer edge, separated from base in its abapical portion; outer lip distinctly bisinuate. Umbilical chink small, distinct, umbilicus minute or absent (figs. 2c, d; 6k-m).

Dimensions	Length	Diameter
Holotype	0.98mm	0.68mm
Paratypes	0.98	0.70
	0.94	0.65
Figured specimens (S.E.M.)		
(Paratypes)	1.03	0.68
	0.98	-
(Deal Is., Tasm.)	0.92	0.65

OPERCULUM: pale yellowish, transparent, a separate muscle insertion area not visible; a weak ridge on columellar edge, peg narrower than typical.

RADULA: central 2 + 1 + 2, lateral 2 + 1 + 3, inner marginal 6 + 1 (1), outer marginal (about 6) (fig. 6n).

Operculum and radula observed from Deal Is., Tasm. (S.E.M. stub no. 128) and operculum from the type locality.

ANIMAL: head-foot unpigmented; visceral mass whitish-yellow to dark grey marbled with black; mantle often marbled with black; animal easily visible through shell (preserved material).

TYPES. Holotype A.M. (C. 102243). Paratypes (9) A.M. (C. 102244). 2 shells and 1 operculum on S.E.M. stub no. 265.

TYPE LOCALITY. S. end of Green Cape, N.S.W., on algae, on exposed coast, 2-4m, 13 Feb. 1973, coll. W. F. Ponder.

ADDITIONAL MATERIAL EXAMINED. *N. Tasm.:* East Cove, Deal Is., Bass Strait, 6-15m, 3-10 May 1974, coll. S. A. Shepherd, S.E.M. stub no. 128 (2/2w). Deal Is., Bass Strait, on algae, 6m, 6 May 1974, coll. S. A. Shepherd (3). *E. Tasm.:* Green Cape, Maria Is., on sublittoral algae, 6m, 26 Mar. 1970, coll. W. F. Ponder and D. C. Wolfe (2). *S. Tasm.:* N. end Pirates Bay, Eaglehawk Neck, low tide, on large brown algae (5); *Lessonia* holdfasts (1), 2 Apr. 1970, coll. W. F. Ponder. Pirates Bay, Eaglehawk Neck, low tide, under stones (3/2w); S. E. side, on brown algae (1/2w), 2 Apr. 1970, coll. W. F. Ponder. Fossil Is., Eaglehawk Neck, 3 June 1967, coll. A. Dartnall (3) (T.M.). *Vic.:* Ocean platform, Flinders on stones and algae in rock pools, low tide, 4 May 1967, coll. B. J. Smith (10w). Western Port, Vic., Gatliff Coll. (2) (N.M.V.). Pt. Lonsdale, on short algae (13); on large brown algae (4); on exposed brown algae (6), 23 Mar. 1975, coll. W. F. Ponder and R. Burn. Pt. Grey, Lorne, on exposed brown algae, 23 Mar. 1975, coll. W. F. Ponder and R. Burn (7w). Moonlight Beach, W. of Cape Otway, on algae on rock platform, 11 Mar. 1973, coll. Marine Study Group (6/3w). *S.A.:* Off Middle Pt., near Cape Northumberland, on algae, 13m (2); 600m from shore, 6m (40/20w), 19 Mar. 1974, coll. S. A. Shepherd. Elliston, on algae, 0-5m, Feb. 1974, coll. V. Taylor (2). *S.W.A.:* Mississippi Bay, 48km E. of Esperance, on sheltered side of west head of bay, 0-2m, on algae, 6 Feb. 1972, coll. W. F. Ponder (5). Bunker Bay, 11km W. of Dunsborough, on short algae, 0-3m, semi-sheltered open coast, 24 Dec. 1971, coll. W. F. Ponder and B. R. Wilson (1).

DISTRIBUTION AND HABITAT. Southern N.S.W., Bass Strait, Tasm., and the S. coast to S.W.A. Mostly found on low tidal or sublittoral algae in rather exposed situations (fig. 12).

REMARKS. This species is easily distinguished from the other small, white species of *Eatoniella* by its minute size, thin shell and strongly bisinuate outer lip. It is not closely allied to any other described species of *Eatoniella*. There is some variation in the relative length of the spire (cf. figs. 6k-m) but otherwise the shell characters are constant.

Eatoniella (Eatoniella) fulva sp. nov. Figs 3g, h; 8a-e.

SHELL: minute, ovate-conical to conical, semi-opaque, brown, with rounded or subangled periphery, non-umbilicate. Protoconch of about 1½ whorls; teleoconch of about 2½ very slightly to moderately convex whorls; body whorl with subangled periphery; spire rather long, outlines almost straight to slightly convex. Aperture simple; inner lip very narrow; outer lip evenly and moderately retracted. Occasionally a minute umbilical chink present. Colour dark yellow-brown, last third of body whorl and sometimes lower base translucent white (figs 3g, h; 8a, b, d).

Dimensions	Length	Diameter
Holotype	1.56mm	1.00mm
Paratypes	1.52	1.04
	1.44	0.98
Figured specimens (S.E.M.)		
(Deal Is., N. Tasm.)	1.66	0.96
	1.52	—
(Hopetoun, S.W.A.)	1.43	0.92

OPERCULUM: dark red-brown, opaque; typical in structure, no internal ridge (fig. 8c).

RADULA: central (1) 1-2 + 1 + 1-2 (1), lateral 2 + 1 + 2, inner marginal 3-4 + 1 (3-5), outer marginal (7) (fig. 8e).

Opercula and radulae observed from Deal Is., N. Tasm. (S.E.M. stub no. 109) and Hopetoun Jetty, S.W.A. (S.E.M. stub no. 182).

ANIMAL: not observed.

TYPES. Holotype A.M. (C. 102245). Paratypes (13) A.M. (C. 102246).

TYPE LOCALITY. South Pt., S. of Two Peoples Bay, near Albany, S.W.A., on algae on exposed shore, 3 Feb. 1972, coll. W. F. Ponder.

ADDITIONAL MATERIAL EXAMINED. *N. Tasm.:* Bass Strait; Deal Is., on algae , 6m, 6 May 1974, coll. S. A. Shepherd (7/9w); Murray Pass., Deal Is., on algae, 30-50m, 9 May 1974, coll. S. A. Shepherd (13/2w); East Cove, Deal Is., 6-15m, 3-10 May 1974, coll. S. A. Shepherd, S.E.M. stub no. 109 (3/5w); Little Squally Cove, Deal Is., on algae, 10-30m, coll. S. A. Shepherd (3w); E. of King Is., 46m, 30 Apr. 1973, B.M.R. stn 2163, M.T. "Sprightly" (2); S.E. of King Is., 55m, 12 Apr. 1973, B.M.R. stn 2112, M.T. "Sprightly" (1); E. of Grassy, King Is., ca. 55-77m, 23 July 1962, H.M.A.S. "Gascoyne" stn G2/68-70/62 (4).*E. Tasm.:* S. of Cape Lodi, 28m, 19 Mar. 1973, coll. P. H. Colman, B.M.R. stn 2015, M.T. "Sprightly" (15). Green Cape, Maria Is., on sublittoral algae, 6m, 26 Mar. 1970, coll. W. F. Ponder and D. C. Wolfe (10). Pirates Bay, Eaglehawk Neck, under stones, 2 Apr. 1970, coll. W. F. Ponder (1). Fossil Is., Eaglehawk Neck, 3 June 1967, coll. A. Dartnall (1) (S.A.M.). W. of West Pt., 80m, 14 Apr. 1973, B.M.R. stn 2117, M.T. "Sprightly" (2). *Vic.:* Warmeet Channel, Western Port, 4m, 15 Feb. 1969, coll. W. F. Ponder and B. J. Smith (15/7w). Pt. Leo, Western Port, Aug. 1956-Feb. 1957, coll. J. Kerslake (1). *S.A.:* Off Beachport, 73m (sev) (S.A.M.). Robe, J. C. Verco Coll. (3) (S.A.M.). W. of Cape Jaffa, 141m, H.M.A.S. "Gascoyne" stn G2/76/62 (9). Guichen Bay, J. C. Verco Coll. (1) (S.A.M.) *S.W.A.:* Mississippi Bay, 48km E. of Esperance,

on algae, 6 Feb. 1972, coll. W. F. Ponder (15). E. side of Hopetoun Jetty, on algae, W. side of sheltered limestone reef, 0-1m, 4 Feb. 1972, coll. W. F. Ponder (1). Hopetoun Jetty, semi-exposed reef and sand, 0-2m, 5 Feb. 1972, coll. W. F. Ponder, S.E.M. stub no. 182 (35/24w). King George Sound, J. C. Verco Coll. (1) (S.A.M.). *W.A.*: W. side Carnac Is., off Fremantle, on algae, 4-8m, 18 Dec. 1971, coll. W. F. and J. M. Ponder, B. R. Wilson and N. Coleman (1/2w). Sheltered part of S. side, Pt. Peron, S. of Fremantle, on algae and *Posidonia* — sand and rock substrate, 27 Jan. 1972, coll. W. F. and J. M. Ponder (2). S. W. end of Garden Is., off Fremantle, on algae, 0-3m, coll. W. F. and J. M. Ponder and N. Coleman (11/12w). W. end of Salmon Bay, Rottnest Is., on *Lithothamnion*, Aug. 1969, coll. S. Slack-Smith (1).

DISTRIBUTION AND HABITAT. Bass Strait, Tasm. and the S. coast to mid W.A., on intertidal and sublittoral algae. The records from the continental shelf refer to dead shells which have probably originated in shallower water (fig. 12).

REMARKS. This species can be distinguished from the other species of *Eatoniella* by its brown colour and red-brown operculum. The radula, too, is distinctive in having several denticles on the outer part of the cutting edge of the inner marginal teeth. Specimens from the western part of the range of this species tend to have a more depressed spire and less conical outline (figs. 3g, h; 8d) than those from Bass Strait (figs. 8a, b). The two forms, however, cannot be consistently separated.

Eatoniella (Eatoniella) galbinia (Laseron, 1950). Figs 2m, n; 8f-n.

Notosetia galbinia Laseron, 1950: 281 fig. 76.

SHELL: minute, rather short-spired, pale, translucent, yellowish to pale greyish, non-umbilicate, with relatively large body whorl and aperture. Protoconch of about 1¾ whorls, dome-shaped; teleoconch of 2½ moderately convex whorls; spire outlines moderately convex. Aperture with well-developed inner lip with a concave outer edge; outer lip strongly retracted, usually slightly to moderately sinuate, sometimes evenly curved. Colour translucent pale yellowish-brown, pale yellowish or pale greyish; lower base and inner lip often white; outer lip same colour as majority of shell (figs 2m, n; 8f-h, j, k, m).

Dimensions	Length	Diameter
Lectotype	1.30mm	0.83mm
Paralectotypes	1.32	0.95
	1.26	0.88
Figured specimens (S.E.M.)		
(North Harbour, N.S.W.)	1.33	0.94
	1.36	-
(Fairlight, N.S.W.)	1.40	0.95
	1.27	-
(Pt. Hicks, Vic.)	1.30	0.93
(Cape Otway, Vic.)	1.20	0.86

OPERCULUM: outer ⅓ and nuclear area dark grey to black, remainder pale yellowish-white, opaque; typical in structure, (figs. 8l, n) without an internal ridge; muscle insertion area over entire surface except below peg.

RADULA: typical; central (1) 2 + 1 + 2 (1), lateral 2 + 1 + 2 (1), inner marginal 4 + 1 + 1, outer marginal (about 5); teeth rather sharp and most moderately long although the secondary cusps on the central teeth are rather shorter than usual (fig. 8i).

Radulae and opercula examined from Cape Otway, Vic. (S.E.M.) stub no. 100), Pt. Hicks, Vic. (S.E.M. stub no. 126) and Fairlight, Sydney, N.S.W. (S.E.M. stub no. 102).

ANIMAL: head-foot yellowish-white except for dorsal foot which is grey to black and head (behind snout) pale grey, details somewhat variable; opercular lobes usually black, no opercular tentacles (Sydney).

TYPES. Lectotype (here chosen) A.M. (C. 102247). Paralectotypes (8) A.M. (C. 102248).

TYPE LOCALITY. North Harbour, Sydney, N.S.W., on algae.

ADDITIONAL MATERIAL EXAMINED. *N.S.W.:* Off Crowdy Head, 91m (1). Forster, on fine brown algae, low tide (5). Port Stephens (1). Little Beach, Port Stephens (3). Off Patonga Beach, Broken Bay (14). Pittwater, Broken Bay (3). *Sydney;* Narrabeen, Collaroy, on algae, 3 lots (22/18w), in shell sand (24); Manly Beach, 2 lots (8); North Harbour, 3 lots (100); Fairlight, on algae, low tide, S.E.M. stub no. 102 (11/8w), on coralline algae (1), under stones (1), on red algae, 7-11m (13/14w); N.E. side of Grotto Pt., Middle Harbour, 5-8m (1); Chinamans Beach, Middle Harbour (1); Middle Harbour (15); Balmoral, on brown algae (3w); Off Sow and Pigs Reef, 3 lots, 11-16m (14); Shark Is., (2); Port Jackson (2); Little Coogee Bay (32); Kurnell, Botany Bay (8); Simpson Bay, Port Hacking, on algae in brackish creek (1); Jibbon Pt., Port Hacking, on algae, 1-2m (13); Gunnamatta Bay, Port Hacking (3). Bass Pt., on brown algae, 20m (5). Werri Beach, (3). Huskisson (3). Honeymoon Beach, Jervis Bay, under stones, low tide (2/2w). Jervis Bay, on red algae, 5m (2). Ulladulla (24). S. side of Ulladulla, on small brown algae (5/7w), on coralline algae (5/3w). Batemans Bay, on coralline algae (20), on large brown algae (30/18w). Merimbula, brackish lake (1). Green Cape, Disaster Bay, under stones, 15m (2). S. end of Green Cape, on algae, 2-4m (50), on algae on vertical rock faces, 16m (50). *N. Tasm.: Bass Strait;* Deal Is., on algae, 6m (5); Murray Pass., Deal Is., on algae, 30-50m (18/43w); Little Squally Cove, Deal Is., 10-30m (13w). Boat Harbour, on short brown algae, 2m (32). *E. Tasm.:* Ansons Bay (2) (T.M.). S. of Cape Lodi, 28m (2). Spring Beach (5) (T.M.). Green Cape, Maria Is., on sublittoral algae, 6m (9). *S. Tasm.:* N. end of Pirates Bay, Eaglehawk Neck, on large brown algae, mid-tide (1), under stones (1), Wedge Bay, 13m (5), 7m (5). Off Fluted Cape, Bruny Is., on algae, 7-10m, (9). *W. Tasm.:* Near Granville Harbour (4) (T.M.). Marrawah (2) (T.M.). *Vic.:* Pt. Hicks (=Cape Everard), on *Phyllospora* holdfasts, 6-9m, S.E.M. stub no. 126 (6), on alcyonarian, 18m (10/7w). E.S.E. side of Gabo Is., on red algae, 28m (10/8w), in detritus, 15-18m (9/10w). San Remo, on algae (1). Honeysuckle Pt., Shoreham on rock and algae (4). Pt. Lonsdale, on short algae (3), on large brown algae (26), loose coralline algae (1). Anglesea (2) (N.M.V.). Pt. Grey, Lorne, on brown algae, low tide (9w). Moonlight Beach, W. of Cape Otway, S.E.M. stub no. 100 (30/12w).

DISTRIBUTION AND HABITAT. Very abundant in N.S. W. and common over the rest of its range (Bass Strait, Tasm, and E. Vic. to mid Vic.). On algae in a variety of exposures in the lower littoral and sublittoral (fig. 1).

REMARKS. Specimens from the vicinity of Bass Strait are generally more ovate (figs 8h, m) and tend to be greyish rather than yellowish like the typical N.S.W. form (figs 2m, n; 8f, g, j, k). The opercular and radular characters, however, do not differ between these populations so that they are considered to be conspecific.

The distinctive features of this species are the rather pale-coloured shell which is usually somewhat translucent, the rounded body whorl, the non-umbilicate base and the convex spire outlines, together with the usually bisinuate outer lip and the yellow and black operculum. *E. (E.) victoriae* nov. is probably the only species with which it can be confused, but that species is larger and has a distinct umbilical chink.

Eatoniella (Eatoniella) hewittae sp. nov. Figs 2g, h; 7m, n.

SHELL: minute, tall spired, translucent white, with 2 narrow purplish-pink bands. Protoconch colourless, of 1¾ whorls; teleoconch of about 2½ weakly convex whorls; spire rather tall, slightly greater than height of aperture, outlines very slightly convex. Aperture relatively small; inner lip narrow, rather thickened, sometimes separated from parietal area by a narrow groove; outer lip slightly bisinuate and retracted. Umbilical chink minute. Colour whitish, with 2 narrow dark purple-pink to paler orange-pink bands, one on periphery and one abapical to suture, both bands clearly visible on spire whorl (figs 2g, h; 7m).

Dimensions	Length	Diameter
Holotype	1.32 mm	0.76 mm
Paratype	1.30	0.80
Figured specimen (Carnac Is., W.A.) (S.E.M.)	1.60	0.84

OPERCULUM: typical, pale yellow in colour.

RADULA: central (1) 2 + 1 + 2 (1), lateral 3*+1*+ 2, inner marginal 5 + 1, outer marginal (about 7) (*These teeth bifurcate, presumably a freak condition. The bifurcation was ignored in the formula) (fig. 7n).

Radula observed from Carnac Is., W.A. (S.E.M. stub no. 246).

ANIMAL: not observed.

TYPES. Holotype A.M.(C. 102249). Paratypes (7) A.M. (C. 102250), 1 W.A.M. (WAM 404-76).

TYPE LOCALITY. Cape Naturaliste, S.W.A., in shell sand, Mar. 1970, coll. Mrs. J. Hewitt.

ADDITIONAL MATERIAL EXAMINED. *S.W.A.:* Ellensbrook, near Margaret River mouth, in shell sand, Jan. 1972, coll. W. Anson (1). Quininup, S.W.A., 1972, coll. J. Hewitt (6). S. of Cowaramup Bay, near Margaret River Mouth, S.W.A., in shell sand, 1972, coll. H. Baker, pres. J. Hewitt (3). Kilcarnup, N. side of Margaret River, in shell sand, 1 Jan. 1972, coll. W. F. Ponder (3). *W.A.:* W. side Carnac Is., off Fremantle, on algae, low tide, 18 Dec. 1971, coll. W. F. & J. M. Ponder, B. R. Wilson & N. Coleman, S.E.M. stub no. 246 (6). Pt. Peron, S. of Fremantle, in shell sand, 3.5m, 27 Jan. 1972, coll. W. F. & J. M. Ponder (2).

DISTRIBUTION AND HABITAT. Uncommon, mid W.A. to S.W.A. On algae in the lower littoral but probably more typical of the sublittoral (fig. 14).

REMARKS. Superficially similar to *E. (E.) puniceolinea* nov. but with a much taller spire, and relatively much smaller aperture. The radular features also separate these species. The primary type series consists of material collected from "shell-sand" and the specimens are slightly worn. The distinctive colour and shape, however, make even badly worn specimens of this species readily distinguishable.

This species is named for Mrs. J. Hewitt of Western Australia who has kindly made much material available to us for study.

Eatoniella (Eatoniella) howensis sp. nov. Figs 1p, q; 7a-c.

SHELL: superficially very similar to *E. (E.) puniceolinea* nov. but slightly smaller, with only 1 prominent median band and a narrow band at the suture. Protoconch of 1½ whorls; teleoconch of about 1¾ whorls. Inner lip of aperture rather broad, abapical portion well

separated from base; outer lip evenly retracted without indentations. Pale yellowish-brown, translucent, the band bright pink; inner lip usually pink or purple within (usually colourless or white in *E. (E.) puniceolinea);* some specimens pale purplish-pink, the band darker purple, inner lip dark purple (figs 1p,q; 7a,b).

Dimensions	Length	Diameter
Holotype	0.73 mm	0.60 mm
Paratypes	0.82	0.66
	0.74	0.60
	0.78	0.60
Figured specimens (S.E.M.) (Phillip Pt., Lord Howe Is.)	0.74	0.56
	0.82	-

OPERCULUM: pale yellowish-white, opaque over nearly all surface (due to extensive muscle insertion area), a narrow internal ridge along columellar edge (fig. 7c).

RADULA: central (1) 2 + 1 + 2 (1), marginal 2 + 1 + 2 (1), inner marginal (? 2) + 1 (1), outer marginal (about 6).

Opercula and radulae examined from off Phillip Point, Lord Howe Is. (S.E.M. stub no. 106).

ANIMAL: head-foot does not appear to be pigmented (preserved material).

TYPES. Holotype A.M. (C. 102251). Paratypes (30) A.M. (C. 102252).

TYPE LOCALITY. Lord Howe Is., outside reef, W. of Erscotts Passage, on steeply sloping bottom, 18-24m, Feb. 1973, coll. J. Randall.

ADDITIONAL MATERIAL EXAMINED. *Lord Howe Is.:* Lord Howe Is., coll. R. Bell (8); N. side of Rabbit Is., below low tide, in sheltered water, on brown algae on coral, 2 Feb. 1971, coll. P. H. Colman (2); Off Phillip Pt., Feb. 1973, coll. J. Randall, S.E.M. stub no. 106 (4/31w); Neds Beach, following storm, Feb. 1973, coll. J. Randall (4); S. W. Corner, W. of King Pt., on algae, littoral zone to 3m, in heavy surf area on rock face, 2 Feb. 1971, coll. P. H. Colman (36).

DISTRIBUTION AND HABITAT. Known only from Lord Howe Island where it occurs in the lower littoral and sublittoral on algae (fig. 11).

REMARKS. The few purple specimens available resemble *E. (E.) atropurpurea* but are smaller and they grade into the typical pink-banded form which they resemble in all other ways. The relationships of this species are with *E. (E.) atropurpurea* and possibly the New Zealand species *E. (E.) roseocincta* (Suter, 1908), rather than with *E. (E.) puniceolinea,* on the basis of the simple aperture and the opercular characters. It differs from the New Zealand species in its smaller size, shape and colour details, *E. (E.) roseocincta* being pink with white bands.

Eatoniella (Eatoniella) juliae sp. nov. Figs 2a, b; 7d-f.

SHELL: minute, rather solid, semi-translucent, colourless or with very pale yellowish tinge, ovate-conical, with rather thickened apertural lips, non-umbilicate. Protoconch of 1½-1¾ colourless whorls, teleoconch of about 2 very lightly convex whorls; spire sometimes lightly convex. Inner lip with usually concave outer edge, separated from base abapically; outer lip evenly retracted. Umbilical chink minute or absent (figs 2a, b; 7d, e).

Dimensions	Length	Diameter
Holotype	1.14 mm	0.80 mm

Paratypes	1.16	0.85
	1.20	0.80
Figured specimens (S.E.M.) (Paratypes)	1.16	0.75
	1.10	-

OPERCULUM: typical, pale yellowish, transparent; muscle insertion area usually very small, confined to a narrow strip along columellar edge, but sometimes broader (up to ⅓ of total surface area), its edge diffuse.

RADULA: central 2 + 1 + 2, lateral 2 + 1 + 2, inner marginal 2 + 1 + 1, outer marginal (? 4). All cusps sharp and rather long, median cusp on central teeth long and narrow (slightly more than 2 x length of adjacent lateral cusps) (fig. 7f).

Opercula and radulae examined from the type locality.

ANIMAL: head-foot and mantle generally unpigmented but sometimes partly grey, visceral mass white or parts of it are pigmented various shades of grey and sometimes uniformly grey (preserved material).

TYPES. Holotype A.M. (C. 102253). Paratypes (20/8w) A.M. (C. 102254), 3 S.A.M. (D. 15253), 3 W.A.M. (WAM 405-76), 10 shells, 1 operculum, 2 radulae on S.E.M.stub nos. 234, 265, 292,492, 507.

TYPE LOCALITY. Near Hopetoun Jetty, S.W.A., on algae, semi-exposed reef, 0.5-2m, 5 Feb. 1972, coll. W. F. Ponder.

ADDITIONAL MATERIAL EXAMINED. *S.A.:* Guichen Bay, J. C. Verco Coll. (1) (S.A.M.). *S.W.A.;* Mississippi Bay, 48km E. of Esperance, on sheltered side of west head of bay, 0-2m, on algae, 0-2m, 6 Feb. 1972, coll. W. F. Ponder (sev). Twilight Cove, 10km E. of Esperance, littoral, medium to high exposure, 8 Dec. 1971, coll. W. F. & J. M. Ponder (7/13w). E. side of Hopetoun Jetty, on algae, W. side of sheltered limestone reef, 0-1m, 4 Feb. 1972, coll. W. F. and J. M. Ponder (1). South Pt., S. of Two Peoples Bay, near Albany, on large brown algae, on exposed shore, 3 Feb. 1972, coll. W. F. Ponder (17). S. of Cowaramup Bay, near Margaret River mouth, coll. H.Baker, pres. J. Hewitt (1). Kilcarnup, N. side of Margaret River, in shell sand (10), on algae (42), 1 Jan. 1972, coll. W. F. Ponder. Yallingup, on limestone platform, on algae, 2 Jan. 1972, coll. W. F. Ponder and B. R. Wilson (52/34w). Cape Naturaliste, in shell sand, Mar. 1970, coll. J. Hewitt (2). N. side of Cape Naturaliste lighthouse, just below low tide, under stones, 30-31 Dec. 1971, coll. W. F. and J. M. Ponder and G. Wilson (4/4w). Bunker Bay, 11km W. of Dunsborough, on intertidal algae (9), on short algae, semi- sheltered open coast, 0-3m (10), 24 Dec. 1971, coll. W. F. Ponder and B. R. Wilson.

DISTRIBUTION AND HABITAT. S.W.A. and 1 dead specimen from S.A. which needs to be confirmed. On algae in the lower littoral and shallow sublittoral; often common (fig. 12).

REMARKS. This species is distinctive in its very small size, rather solid, virtually colourless shell and rather heavy apertural lips. It approaches *E. (E.) exigua* in general features but that species is smaller, has a thinner shell with a relatively larger aperture, shorter spire and has a sinuate outer lip and the radula and opercular features are also very different.

This species has been named for Mrs. Julie Ponder, for her considerable help in numerous ways to us.

Eatoniella (Eatoniella) melanochroma (Tate, 1899). Figs 3a-d; 9a-m.

Rissoa melanura T. Woods, 1877:153.

Rissoia (Cingulina) melanura. — Tryon, 1887:358, pl. 71, fig. 7.

Rissoia (Cingulina) melanochroma Tate, 1899:234 (nom. nov. pro *R. melanura* T. Woods, 1877, non C. B. Adams, 1850).

Rissoia melanochroma. — Tate and May, 1901:393.

Rissoa melanochroma. — Pritchard and Gatliff, 1902:106.

Dardanula melanochroma. — May, 1921:50; May, 1923, pl. 23, fig. 30; Cotton, 1944:305.

SHELL: conical, rather solid, thick-shelled, opaque to translucent, non-umbilicate, usually uniform grey to black, sometimes brown and white. Protoconch of 1½ usually pigmented whorls; teleoconch up to 3¼ weakly convex whorls; spire outline very slightly convex. Aperture with outer lip sharply and evenly retracted or weakly to moderately bisinuate; inner lip rather narrow, its outer edge concave. Usually paler in colour behind outer lip and within aperture than over rest of shell; outer lip usually with a dark grey, brown or black edge within, although some pale shells lack this feature; remainder of shell typically dark grey to black but sometimes (nearly always on the west coast) brown to yellowish-brown, with whitish bands on base and adapical to suture (figs 3a-d; 9a, b, g-j).

Dimensions	Length	Diameter
Lectotype	2.10 mm	1.20 mm
Figured specimens (S.E.M.)		
(Yallingup, S.W.A.)	1.52	0.94
	1.44	-
(Shoreham, Vic.)	1.80	1.14
	1.66	-
(Hopetoun, S.W.A.)	1.78	1.04
	1.55	-

OPERCULUM: externally grey thinly spread over yellow, with black edges, opaque, muscle insertion area over whole surface above peg; typical in structure (figs 9c, d, l), with a narrow ridge along columellar edge and a broad, low internal ridge; weak, indistinct spiral grooves externally.

RADULA: typical, central (1) 2 + 1 + 2 (1), lateral 2 + 1 + 2 (1), inner marginal 3-4 + 1 (1), outer marginal (6-8); all teeth rather long and sharp, 1 specimen with 3 teeth on inside of primary cusp on each lateral tooth (Elliston Bay, S.A.) (figs 9e, k, m).

Opercula and radulae examined from Shoreham, Vic. (S.E.M. stub nos 82, 95), Hopetoun Jetty, S.W.A. (S.E.M. stub no. 236) and Yallingup, S.W.A. (S.E.M. stub no. 235).

ANIMAL: head-foot lightly pigmented, greyish; snout sometimes black, tentacles colourless; opercular lobes grey to black, with a single black opercular tentacle on left lobe (Eaglehawk Neck, S. Tasm.)

TYPES. Lectotype (here chosen) and 2 paralectotypes T.M. (TM 5477).

TYPE LOCALITY. Blackmans Bay, S. Tasm.

ADDITIONAL MATERIAL EXAMINED. *N.S.W.:* Wimbie Beach, Batemans Bay, on large brown algae (2). Bitangabee, N. side of Green Cape, on coralline algae in sheltered pool (4). S. end of Green Cape, on algae, 2-4m (5), on coralline algae (1). *N. Tasm.:* East

Cove, Deal Is., Bass Strait, 6-15m (20), Bass Strait (1), Just N. of Waterhouse Is., 40m (1) (T.M.). Kelso (2). Badger Head, Tamar River mouth (5) (T.M.). Boat Harbour, on brown algae (65), on short brown algae (60), on coralline algae (5). Goat Is., near Ulverstone, on brown algae (2). Freestone Cove, Wynyard, on algae, low tide (22). West Head, Green Beach, under stones and on coralline algae, low tide (15). Fraser Bay, King Is. (2). Cowry Pt. (16) (T.M.). *E. Tasm.:* Green Cape, Maria Is., on algae, sublittoral (50). *S. Tasm.:* Pirates Bay, Eaglehawk Neck, on coralline algae (80/41w), on brown algae (183/17w), on *Caulerpa* (50/17w), under stones (30). Eaglehawk Neck (80) (4 in T.M.). Cape Pillar, 183m (1). Nubeena, Wedge Bay, 7m (42). Primrose Pt., E. side of Frederick Henry Bay, on coralline algae, low tide (35), on matted green algae (60/35w), on various brown algae (95/22w). Roches Beach, W. side of Frederick Henry Bay, semi-sheltered reef, on matted green algae (45), on brown algae (450/200w), on coralline algae, S.E.M. stub no. 33 (50/50w), on short brown algae (45/35w). Dunalley (3) (T.M.). Off Fluted Cape, Bruny Is., on algae, 7-10m (5). Tinderbox (sev) (T.M.). Browns River (sev). *W. Tasm.:* W. of West Pt., 80m (1). *Vic.:* Torquay (2) (N.M.V.) Queenscliff (sev) (N.M.V.). Merricks, Western Port, on coralline algae (24), on brown algae (5). Portsea, 2 lots (sev) (sev in N.M.V.). Flinders, on rocks and algae, low tide (150/120w). Honeysuckle Pt., Shoreham, on rocks and algae, S.E.M. stub nos. 82, 95 (150/100w). Fossil Beach, Mornington (4). Frankston (sev) (N.M.V.). Queenscliff, Port Phillip, on small algae (20/8w). Pt. Lonsdale, on large brown algae (22); on coralline algae (47); on short algae (20). Pt. Grey, Lorne, on brown algae, low tide (45/38w). Moonlight Beach, W. of Cape Otway (80/50w). Port Fairy, on brown algae (12), on coralline algae (9), on short algae (14) (1 in N.M.V. and 8 in S.A.M.). Portland (few) (N.M.V.). *S.A.:* McDonnell Bay (sev) (S.A.M.). Off Middle Pt., near Cape Northumberland, 600m from shore, on algae, 6m (16/5w). Robe (sev) (S.A.M.). Guichen Bay (sev) (S.A.M.). W. of Cape Jaffa, 141m (1). Kingstone (1) (S.A.M.). Normanville, Gulf St. Vincent, 2 lots (16). Yankalilla Bay (1) (S.A.M.). Blanche Pt., N. of Aldinga, on short brown algae (2). Hardwicke Bay, 2 lots (sev) (S.A.M.). Henley Beach (1). Off Cape Borda, 100m, 3 lots (sev-Pleistocene?) (S.A.M.). Arno Bay (4). Tumby Bay (sev). Near Salmon Pt., Elliston Bay, on *Cystophora,* 1m, S.E.M. stub no. 123 (54). Elliston, on algae, 0-5m (35). Waldegrave Is., on algae, 1m, 2 lots (6). Venus Bay (2) (S.A.M.). Franklin Is. (2) (S.A.M.). St. Francis Is., 11m, 2 lots (sev) (S.A.M.). Pt. Sinclair, on algae, 0-1m, semi-sheltered (sev). *S.W.A.:* Great Australian Bight (S.W. of Eucla), 75m (7). Mississippi Bay, 48km E. of Esperance, on algae, 0-2m (25). Twilight Cove, 9km E. of Esperance, on algae, low tide, 2 lots (3). E. side of Hopetoun Jetty, on algae, 0-1m (15). Hopetoun Jetty, on algae, 0-2m, S.E.M. stub no. 236 (11). Hopetoun (1) (S.A.M.). South Pt., S. of Two Peoples Bay. near Albany, on large brown algae, on exposed shore (10). King George Sound (sev) (S.A.M.). Ellensbrook, near Margaret River mouth (1). Kilcarnup, N. side of Margaret River mouth, on algae (sev); in shell sand (sev). Yallingup, on algae, S.E.M. stub no. 235 (211). Wyadup, 6km S. of Yallingup, on large brown algae (1). N. side of Cape Naturaliste lighthouse, low tide (25). Cape Naturaliste (1).

DISTRIBUTION AND HABITAT. Southern N.S.W., Tasm., Vic., S.A. and S.W.A. On algae and beneath stones in the littoral and shallow sublittoral; often very abundant (fig. 12).

REMARKS. This species is similar to *E. (E.) olivacea* (Hutton, 1882) from New Zealand but that species is larger and more conical in shape, shows a different series of colour variations and the animal has no opercular tentacles (Ponder, 1965). The only similar Australian species are *E. (E.) atrella* and *E. (E.) galbinia,* both of which are smaller.

Two colour forms of this species are found throughout its range along the south coast and Tasmania. The common form is black or grey (figs 3c, d; 9a, b) but some specimens are pale (usually white and brown), often thin-shelled, translucent and have a tendency towards a more pronounced bisinuation of the outer lip (figs 3a, b; 9i, j). The

frequency of this pale form seems to increase from east to west and samples from the west coast show only the pale form present. West coast specimens are also slightly smaller and more ovate than most of the southern material. The shell characters of the two forms clearly merge in south coast populations and they appear to be identical in opercular, radular and head-foot characters.

Eatoniella (Eatoniella) puniceolinea sp. nov. Figs 1n, o; 6d-j.

SHELL: minute, ovate-conical to conical, usually short-spired, translucent, pale yellowish with 1-2 pink bands, with relatively large body whorl and aperture. Protoconch colourless, of about 1½ whorls· teleoconch of up to 2¼ convex whorls; spire short, with convex outlines. Aperture with inner lip projecting from base, rather narrow in its middle portion; outer lip retracted, bisinuate. Umbilical chink distinct, sometimes a very narrow umbilicus present. Colour pale yellowish, usually with pink bands, one abapical to suture and one peripheral, the latter adapical to suture on spire whorl; either or both bands may be sharp and bright, diffuse or absent; outer lip often pink (figs 1n, o; 6d, h).

Dimensions	Length	Diameter
Holotype	1.05 mm	0.84 mm
Paratypes	1.04	0.78
	1.03	0.77
	1.00	0.77
Figured specimens (S.E.M.)		
(Deal Is., N. Tasm.)	1.08	0.80
(Carnac Is., W.A.)	1.02	

OPERCULUM: pale yellowish with the darkly pigmented opercular lobes showing through; structure typical, with a ridge along inside of columellar side; muscle insertion area occupying about ¾ of surface, from columellar edge (figs 6e, i).

RADULA: central 2 + 1 + 2, median tooth nearly 3 times longer than others, lateral 2 + 1 + 2 (1), inner marginal 2 + 1 + 1 (1), outer marginal (about 5) (6f, g), inner marginal variety (see below) 3 + 1 + 1 (1).

Opercula and radulae observed from Deal Is., N. Tasm. (S.E.M. stub no. 108) and Carnac Is., W.A. (S.E.M. stub no. 105).

ANIMAL: head-foot and mantle with black pigment usually present but variable in extent (preserved material).

TYPES. Holotype A.M. (C. 102255). Paratypes (22) A.M. (C. 102256).

TYPE LOCALITY. South Pt., S. of Two Peoples Bay, near Albany, S.W.A., on large brown algae on exposed shore, 3 Feb. 1972, coll. W. F. Ponder.

ADDITIONAL MATERIAL EXAMINED. *N.S.W.*: North Harbour, Sydney, 1950-1960, J. Voorwinde Coll. (1). Little Coogee Bay, Sydney, 21 Apr. 1895, coll. J. Brazier, 2 lots (6). Outside breakwater, S. side of Ulladulla, on medium size brown algae, 5 Jan. 1970, coll. W. F. Ponder and P. H. Colman (1). S. end of Green Cape, on algae on exposed coast, 2-4m, 13 Feb. 1973, coll. W. F. Ponder (24). *N. Tasm.*: Bass Strait; Deal Is., on algae, 6m, 6 May 1974, coll. S. A. Shepherd (9); East Cove, Deal Is., 6-15m, 3-10 May 1974, coll. S.A. Shepherd (5); Murray Pass., Deal Is., on red algae, 30-50m, 9 May 1974, coll. S. A. Shepherd (3); Little Squally Cove, Deal Is., on algae, 10-30m, 4 May 1974, coll. S. A. Shepherd, S.E.M. stub no. 108 (2/2w). Boat Harbour, on *Galeolaria*, 19 Mar. 1975, coll. W. F. Ponder and R. Kershaw (1). Boat Harbour, E. side of headland, on short brown algae, 2m, 19 Mar. 1975, coll. W. F. Ponder (18). *Vic.*: Western Port, dredged, Gatliff Coll. (sev)

(N.M.V.). Ocean side of Queenscliff, Port Phillip, on algae, on rocky platform, 13 Feb. 1969, coll. W. F. Ponder (1). Pt. Lonsdale, on short algae, exposed edge of platform, 22 Mar. 1975, coll. W. F. Ponder and R. Burn (1). Anglesea, Gabriel Coll. (4) (N.M.V.). *S.A.:* MacDonnell Bay, J.C. Verco Coll. (1) (S.A.M.). Guichen Bay, J.C. Verco Coll. (sev) (S.A.M.). Near Salmon Pt., Elliston Bay, on *Cystophora,* 1m, Oct. 1973, coll. S. A. Shepherd (4/2w). Pearson Is., on algae, 18m, Jan. 1973, coll. V. Taylor (5). Tumby Bay, in shell sand, coll, J. Thompson (1). Waldegrave Is., W. side Eyre Peninsula, on algae, 25 Oct. 1973, coll. S. A. Shepherd (1). St. Francis Is., Nuyts Archipelage, 15-37m, 7 Jan. 1971, coll. N. Coleman (2). *S.W.A.:* S. of Cowaramup Bay, near Margaret River mouth, in shell sand, 1972, coll. H. Baker, pres. J. Hewitt (10). Kilcarnup, N. side of Margaret River, on algae, low tide neap, 1 Jan. 1972, coll. W. F. Ponder (1). Off Dunsborough, on *Cymodocea,* 1-2m, 24 Dec. 1971, coll. W. F. Ponder (1). Bunker Bay, 11km W. of Dunsborough, on short algae, semi-sheltered open coast, 0-3m, 24 Dec. 1971, coll. W. F. Ponder and B. R. Wilson (9). *W.A.:* W. side Carnac Is., off Fremantle, on algae, low tide (1), on algae , 4-8m (20/6w), 18 Dec. 1971, coll. W. F. and J. M. Ponder, B. R. Wilson and N. Coleman. Pt. Peron, S. of Fremantle, in shell sand, 2-3m, 27 Jan. 1972, coll. W. F. and J. M. Ponder (4). S. W. end of Garden Is., off Fremantle, on algae, 0-3m, 21 Jan. 1972, coll. W. F. and J. M. Ponder and N. Coleman (28/25w). West end reef, Rottnest Is., on *Lithothamnion* on intertidal reef edge, Aug. 1969, coll. S. Slack-Smith (1). Cottesloe Reef, on algae, 20 May 1970, coll. S. Slack-Smith (1/1w). Horrocks Beach, N. of Geraldton, on algae, on limestone platform, 9 Jan. 1972, coll. W. F. Ponder (1).

E. cf. *puniceolinea.*

W.A.: W. side Carnac Is., off Fremantle, on algae, 4-8m, 18 Dec. 1971, coll. W. F. and J. M. Ponder, B. R. Wilson and N. Coleman, S.E.M. stub no. 105 (87/15w). S.W. end of Garden Is, off Fremantle, on algae, 0-3m (5); on beach (7), 21 Jan. 1972, coll. W. F. and J. M. Ponder and N. Coleman.

DISTRIBUTION AND HABITAT. Mid N.S.W., S. to Bass Strait and N. Tasm., and W. from Vic. to mid W.A. On algae in the lower littoral and shallow sublittoral (fig. 13).

REMARKS. Although very similar to *E. (E.) hewittae* in colour pattern, *E. (E.) puniceolinea* has a much shorter spire and a distinctly bisinuate outer lip. *E. (E.) puniceolinea* differs from all other species in its small size, rather globose shape, bisinuate outer lip, and (usually) pink bands. Occasional specimens completely lack these bands but are distinguishable by their shell shape and size, indentations in the outer lip and often pale yellow shell. Three lots from mid Western Australia (listed as cf. *puniceolinea* above) are consistently translucent white and the outer lip is straighter (fig. 6h), but otherwise are similar in shell, opercular (6i) and radular features, although the inner marginal teeth show 3, not 2 cusps on the inner side of the primary cusp (fig. 6j).

Eatoniella (Eatoniella) shepherdi sp. nov. Figs 1j, k; 5l-p.

SHELL: minute, semi-transparent, almost colourless to yellowish-white, spire rather short, body whorl and aperture large. Protoconch colourless of about 1¾ whorls; teleoconch of 2 convex whorls; spire rather short, outlines very slightly convex (almost straight), body whorl large. Aperture with rather broad inner lip strongly concave on its outer edge; outer lip retracted, usually very broadly bisinuate. Umbilical chink moderate to small. Colourless to white with a yellowish tinge (figs 1j, k; 5l, m).

Dimensions	Length	Diameter
Holotype	1.12 mm	0.88 mm

Paratypes	1.08	0.88
	1.02	0.84
	1.10	0.85
Figured specimens (S.E.M.) (Paratypes)	1.25	0.97
	1.20	-

OPERCULUM: yellow, opaque, muscle insertion area occupying all but that area above peg, usually edges narrowly lined with dark grey; typical structure, with a weak ridge immediately inside columellar edge (figs 5n, o).

RADULA: central (1) 2 + 1 + 2 (1), lateral 2 + 1 +2 (1), inner marginal 3 + 1 + 1 (or (1)), outer marginal (about 7); central tooth with long median cusp (about 2 x length of adjacent marginal cusp), parallel-sided, with rather blunt end (fig. 5p).

Opercula and radulae examined from the type locality.

ANIMAL: head-foot lightly pigmented with grey or unpigmented; visceral mass predominantly black or dark grey and clearly visible through shell (preserved material).

TYPES. Holotype A.M. (C. 102257). Paratypes (37/40w) A.M. (C. 102258), 3 T.M. (E9242), 2 shells, 4 opercula and 4 radulae on S.E.M. stub no. 101.

TYPE LOCALITY. East Cove, Deal Is., Bass Strait, N.Tasm., 6-15m, 3-10 May 1974, coll. S. A. Shepherd.

ADDITIONAL MATERIAL EXAMINED. *N. Tasm.:* Bass Strait; Deal Is., on algae, 6m, 6 May 1974, coll. S. A Shepherd (10); Little Squally Cove, Deal Is., on algae, 10-13m, 4 May 1974, coll. S. A. Shepherd (7); Murray Pass., Deal Is., on algae, 30-50m, 8 May 1974, coll. S. A. Shepherd (4). *E. Tasm.:* Ansons Bay, 28 Dec. 1966, coll. A. Dartnall (3) (T.M.). *S. Tasm.:** N. of Cape Pillar, 95m, in medium sand and bryozoa, 13 Mar. 1973, coll. P. H. Colman, B.M.R.stn 1986, M.T. "Sprightly" (1) *W. Tasm.:* Near Granville Harbour, 23 Nov. 1967, coll. A. Dartnall (11) (T.M.). *S.A.:** Tumby Bay, in shell sand, coll. J. Thompson (2). *Identification doubtful.

DISTRIBUTION AND HABITAT. Bass Strait and E. and W. Tasm. (and possibly S.A.), on sublittoral algae (fig. 13).

REMARKS. This species is superficially similar to *E. (E.) atropurpurea* and lives sympatrically with it in Bass Strait. When *E. (E.) shepherdi* is contrasted with specimens of *E. (E.) atropurpurea* collected with it, it is slightly larger, shorter-spired with a relatively more inflated body whorl and with a more prominent umbilical chink. The colour of the shell differs considerably in the two species, *E. (E.) atropurpurea* being purplish-red to pink but there is no trace of this coloration in *E. (E.) shepherdi*. The radulae of the two species are very similar although the shape of the primary cusp of the central teeth differs, that of *E. (E.) atropurpurea* being sharper and more triangular in form. *E. (E.) puniceolinea* is similar in size and in general shape but can be distinguished by its more ovate outline (due to the relatively smaller body whorl and more convex spire outline), and different coloration.

This species is named for Mr. Scoresby Shepherd of the Department of Agriculture and Fisheries, S.A. who has collected many valuable samples for the writers.

Eatoniella (Eatoniella) talboti sp. nov. Figs 2e, f; 6o, p.

SHELL: minute, ovate-conical, translucent white, umbilicate. Protoconch of 1½ whorls, transparent, shining, teleoconch of 2¼ convex whorls, with dull surface; spire short, broad, body whorl large. Aperture ovate; inner lip moderately thickened, with

concave inner edge; outer lip moderately and evenly retracted, slightly thickened within. Umbilical chink distinct, umbilicus small. Colour translucent white to very pale yellowish-white (figs 2e, f).

Dimensions	Length	Diameter
Holotype	0.90 mm	0.68 mm

OPERCULUM: white, opaque, with distinct ridge inside columellar edge (fig. 6o).

RADULA: central (1) 2 + 1 + 2 (1), median cusp long, narrow, about twice length of adjacent cusps; lateral 2 + 1 + 2, inner marginal 3 + 1 + 1, outer marginal several small sharp cusps (fig. 6p).

Operculum and radula examined from the type locality.

ANIMAL: not observed.

TYPES. Holotype A.M. (C. 102324). Paratype (1) A.M. (C. 102325), 1 operculum and 1 radula on S.E.M. stub no. 262.

TYPE LOCALITY. South outer face of One Tree Is., Capricorn Group, Qld, 2-5m, 7 Dec. 1966, coll. F. H. Talbot.

DISTRIBUTION AND HABITAT. Known only from the type locality (fig. 11).

REMARKS. This tropical species is superficially similar to the southern Australian *E. (E.) depressa* nov. but differs notably in its relatively taller spire and evenly retracted outer lip. *E. (E.) howensis* nov. is similar in size and shape but differs markedly in colour and in minor radular details, although the latter may not be consistent if a larger series were examined.

This species has been named for Professor F. H. Talbot of Macquarie University and previously Director of the Australian Museum.

Eatoniella (Eatoniella) taylorae sp. nov. Figs 3k, l; 10a-c.

SHELL: minute, conical, semi-opaque to translucent, white, umbilical chink small or absent. Protoconch colourless of about 1½ whorls; teleoconch of 3 weakly convex whorls; spire of moderate length, outlines slightly convex to almost straight. Aperture simple; inner lip moderately thickened, raised above parietal area and separated from base abapically; outer lip slightly and evenly retracted (figs 3k, l; 10a, b).

Dimensions	Length	Diameter
Holotype	1.62 mm	1.00 mm
Paratypes	1.60	1.10
	1.62	1.02
Figured specimens (S.E.M.) (Paratypes)	1.77	1.04
	1.50	-

OPERCULUM: yellowish-white, opaque; structure typical, a weak ridge just inside rim of columellar edge.

RADULA: central (1) 2 + 1 + 2 (1), lateral 2 + 1 + 2 (1), inner marginal 3 + 1 (1), outer marginal (about 6); median cusp on central teeth narrow, sharp and long (about 2 x length of adjacent lateral cusp) (fig. 10c).

Operculum and radula observed from the type locality.

ANIMAL: head-foot unpigmented (preserved material).

TYPES. Holotype A.M. (C. 102259). Paratypes (32) A.M. (C. 102260), 3 S.A.M. (D. 15254), 3 W.A.M. (WAM 406-76), 4 shells, 1 operculum and 3 radulae on S.E.M. stub nos. 237, 266.

TYPE LOCALITY. Elliston, S.A., on algae, 0-5m, Feb. 1974, coll. V. Taylor.

ADDITIONAL MATERIAL EXAMINED. *S.A.:* Near Salmon Pt., Elliston Bay, on *Cystophora,* 1m, Oct. 1973, coll. S.A. Shepherd (1). Venus Bay, J. C. Verco Coll. (2) (S.A.M.). Pt. Sinclair, on algae, 0-1m, semi-sheltered, 9 Feb. 1972, coll. W. F. and J. M. Ponder (sev). Fowler Bay, Tate Coll. (sev) (S.A.M.). *S.W.A.:* Hopetoun Jetty, 0-2m, on semi-sheltered reef, 5 Feb. 1972, coll. W. F. Ponder (1). Yallingup, on algae on limestone platform, 2 Jan. 1972, coll. W. F. Ponder and B. R. Wilson (3). South Cowaramup, on beach, 1972, coll. H. Baker, pres. J. Hewitt (2). *W.A.:* Cockburn Sound, 1.5km S.W. of Woodmans Pt., J. Voorwinde Coll. (1). S.W. end of Garden Is., off Fremantle, 21 Jan. 1972, coll. W. F. and J. M. Ponder and N. Coleman (3). Pt. Peron, S. of Fremantle, on exposed S. W. side, in shell sand, 2-3m, 27 Jan. 1972, coll. W. F. and J. M. Ponder (3).

DISTRIBUTION AND HABITAT. S.A. and S.W.A., in the lower littoral and sublittoral on algae; not common (fig. 13).

REMARKS. This species is very similar to *E. (E.) victoriae* and is compared with that species below (see "Remarks" under *E. (E.) victoriae).*

This species is named for Mrs. Valerie Taylor who collected the type series and who has generously donated other valuable material to the Australian Museum.

Eatoniella (Eatoniella) victoriae sp. nov. Figs 3i, j; 10d-g.

SHELL: minute, conical to ovate-conical, semi-opaque, white, with large umbilical chink. Protoconch of about 1⅔ colourless whorls; teleoconch of 3 weakly convex whorls; spire moderate, outlines slightly convex. Aperture with well-developed inner lip raised slightly from parietal area and separated from base abapically, outer lip evenly retracted. Umbilical chink pronounced, umbilicus very narrow or absent. Colour very pale yellowish-white to white (figs 3i, j; 10d, e).

Dimensions	Length	Diameter
Holotype	1.40 mm	0.97 mm
Paratypes	1.54	0.98
	1.48	1.06
Figured specimens (S.E.M.) (Paratypes)	1.50	1.00
	1.44	-

OPERCULUM: outer half and nuclear area usually dark grey to pale brown, middle area yellow, opaque but sometimes entire operculum yellow; muscle insertion area over most of surface (fig. 10f).

RADULA: central (1) 2 + 1 + 2 (1), lateral 2 + 1 + 2 (1), inner marginal 2 + 1 + 1, outer marginal (?6); median cusp of central tooth long (about 2 x length of adjacent teeth), broad, with parallel sides and with a rounded end (fig. 10g).

Opercula and radulae observed from the type locality.

ANIMAL: head-foot pigmented (preserved material).

TYPES. Holotype A.M. (C.102261). Paratypes A.M. 10/2w (C. 102262), 33/5w (C. 102506), 3 N.M.V. (F30006), 2 shells, 2 opercula and 2 radulae on S.E.M. stub no. 110.

TYPE LOCALITY. Between Eagle and Crawfish Rock, N.W. Arm, Western Port, Vic., 4-6m, 15 Feb. 1969, coll. W. F. Ponder, B. J. Smith and J. Watson.

ADDITIONAL MATERIAL EXAMINED. *Vic.:* Western Port, dredged (sev) (N.M.V.). Shoreham, Western Port, Gatliff coll. (sev) (N.M.V.). Off Portsea, dredged, Gabriel Coll. (7) (N.M.V.). Portarlington, Port Phillip Bay, outer side of reef on algae, low tide, 22 Mar. 1975, coll. W. F. Ponder and R. Burn (sev).

DISTRIBUTION AND HABITAT. Western Port and Port Phillip Bay, Vic., on low tidal and sublittoral algae (fig. 13).

REMARKS. This species is very similar to *E. (E.) taylorae* and almost indistinguishable from it on shell features, although *E. (E.) victoriae* usually has a more pronounced umbilical chink. The radula shows differences in the cusp formula of the inner marginal teeth and in the shape of the primary cusp of the central teeth. The operculum is usually darkly coloured in *E. (E.) victoriae* but not in *E. (E.) shepherdi* and this character is probably the most easily used distinguishing feature. The head-foot is pigmented in *E. (E.) victoriae* and not in *E. (E.) shepherdi* and this region of the animal is visible through the shell in both species. *E. (E.) victoriae* also somewhat resembles *E. (E.) galbinia* but is larger, more conical and more nearly white in colour rather than yellow or grey and usually has a distinct umbilical chink. The operculum in *E. (E.) galbinia* is similar in colour but the radula differs in detail, noticeably in the number of cusps on the inner marginal teeth and in the shape of the median cusp on the central teeth.

Subgenus **Albosabula** Ponder, 1965:61.

Type species (original designation): *Rissoa lampra* Suter, 1908.

DIAGNOSIS. Shell conical, solid, opaque, white, apertural lips thickened within; outer lip only slightly retracted. Operculum as in *Eatoniella* s.s. Radula with central teeth similar to those of *Eatoniella* s.s. but the basal margin of each protrudes ventrally in a tongue-like extension and the latero-basal projections are not as heavy; inner marginal teeth with many small cusps.

REMARKS. The differences exhibited by the central teeth, coupled with the rather distinctive shell features, suggest that subgeneric status can be maintained for this group. Three species, all from southern New Zealand, are included in this subgenus by Ponder (1965) and a possible additional species is *Rissoa georgiana* Martens and Pfeffer, 1886 from South Georgia.

Eatoniella (Albosabula) pellucida (Tate & May, 1900). Figs 2l; 7g-i.

Rissoia (Nodulus) pellucida Tate and May, 1900:100.
Rissoia pellucida. — Tate and May, 1901:394, pl. 23, fig. 8.

Amphithalamus pellucidus. — Hedley, 1911:107.

Notosetia pellucida. — May, 1921:53; May 1923, pl. 25, fig. 3; Cotton, 1944:304.

SHELL: minute, solid, opaque, white, non-umbilicate, spire rather tall, aperture relatively small. Protoconch of 1½ whorls; teleoconch of up to 3 very lightly convex whorls, spire outlines slightly convex. Aperture with lips rather thickened within; inner

lip narrow, not much separated from base; outer lip simple, hardly reflected. No umbilicus or umbilical chink present (figs 2l; 7g, h).

Dimensions	Length	Diameter	
Holotype	1.20 mm	0.75 mm	(from original description)
Figured specimens (S.E.M.)			
(Eaglehawk Neck, S. Tasm.)	1.25	0.80	
	1.20		

OPERCULUM: pale yellowish-brown, opaque, typical in structure; muscle insertion area over whole surface except below peg.

RADULA: central 2 + 1 + 2, lateral (1) 2 + 1 + 2 (1), inner marginal 5 + 1 + (1), outer marginal (about 7); central teeth with rather weak lateral projections and a tongue-like extension ventrally (fig. 7i).

Operculum and radula examined from Pirates Bay, Eaglehawk Neck, S. Tasm. (S.E.M. stub no. 125).

ANIMAL: not observed.

TYPES. Holotype, T.M. (7778/E437, TM 10888).

TYPE LOCALITY. Frederick Henry Bay, S. Tasm.

ADDITIONAL MATERIAL EXAMINED. *N. Tasm.:* West Head, Green Beach, on coralline algae and under stones, low tide (5). *E. Tasm.:* Ansons Bay (1) (T.M.). Rheban (1) (T.M.). *S. Tasm.:* Pirates Bay, Eaglehawk Neck, 3 lots (5); under stones, S.E.M. stub no. 125 (2/1w), under stones (9). Primrose Pt., E. side of Frederick Henry Bay, on algae, low tide (3), on green algae (1). Tinderbox (2) (T.M.). *W. Tasm.:* W. of West Pt., 80m (1).

DISTRIBUTION AND HABITAT. Tasm., lower littoral on algae and under stones. The record from the continental shelf is a "dead" shell probably derived from shallow water (fig. 14).

REMARKS. This Australian species is larger than any of the three New Zealand species and has a thicker, denser shell. It can be easily distinguished from *E. (E.) juliae* nov., which is the most similar Australian species, by its opaque-white shell and more conical spire.

Pritchard and Gatliff's (1906) record of this species from Anglesea, Vic. is based on specimens of *E. (E.) puniceolinea* nov., *E. galbinia* and *E. depressa* nov.

Rissoina pellucida Preston (1905:5, pl. 1, fig. 17) is an *Eatoniella* and becomes a secondary homonym of *Rissoia pellucida* Tate and May, 1900. A replacement name is given below.

Genus **Crassitoniella** Ponder, 1965:93.

Type species (original designation): *C. carinata* Ponder, 1965.

DIAGNOSIS. Shell minute, ovate-conical to conical, similar to that of *Eatoniella;* sculpture absent or a weak peripheral cord. Operculum broad, with strong internal ridge, muscle-insertion area not opaque, columellar margin strongly convex, peg straight, in approximately same plane as rest of operculum. Radula as described for family, central teeth with a tongue-like ventral extension bearing a small pair of basal

processes in addition to the larger latero-basal processes. Animal without opercular lobe tentacles.

REMARKS. The opercular and radular features readily separate this genus from *Eatoniella*. Ponder's (1965) illustration of the central tooth of the radula of *C. carinata* is probably inaccurate as far as the basal features are concerned.

Crassitoniella erratica erratica (May, 1912). Figs 4a-e; 10h-k.

Amphithalamus erratica May, 1912:48, pl. 2, fig. 7.

Amphithalamus aurantiocinctus May, 1915:96, pl. 6, fig. 33.

Rissoa aurantiocincta. — Gatliff and Gabriel, 1916:110.

Dardanula erratica. — May, 1921:50; May, 1923, pl. 23, fig. 28; Cotton, 1944:305; Laseron, 1950:273, fig. 48.

Dardanula aurantiocincta. — May, 1921:50; May, 1923: pl. 23, fig. 26; Cotton, 1944:306.

SHELL: minute, conical, translucent, white to yellowish sometimes with two orange bands on body whorl. Protoconch of 1½ whorls; teleoconch of about 4 very slightly convex whorls. Aperture almost circular, with weak to moderate varix placed somewhat behind reflected edge of outer lip; inner lip narrow, rather thin. A very minute umbilical chink sometimes present but this usually absent. Colour white to yellowish-orange, sometimes with a narrow orange band just adapical to periphery (also visible on spire whorls adapical to suture) and another on middle of base (figs 4a-e; 10h).

Dimensions	Length	Diameter	
Holotype	2 mm	1.3 mm	(from original description)
Holotype of *Amphithalamus aurantiocinctus*	2.5	1.4	(from original description
Figured specimen (S.E.M.) (Western Port, Vic.)	2.04	1.20	

OPERCULUM: similar to that of *Crassitoniella flammea,* transparent, yellowish with strong internal ridge and straight peg (fig. 10j).

RADULA: central 1 + 1 + 1, median cusp large, blunt, lateral 1 + 1 + 3, cusps small, inner marginal 2 + 1 + 3, median cusp rather large, sharp; outer marginal (about 6), long and curved (figs 10i, k).

Opercula and radulae examined from off Moreton Bay, Qld (S.E.M. stub no. 127) and Western Port, Vic. (S.E.M. stub no. 124).

ANIMAL: head-foot unpigmented (preserved material).

TYPES. *A. erratica*. Holotype and 20 paratypes T.M. (TM 11757, E. 399/7740). Paratypes 3 N.M.V. (no number), 2 S.A.M. (no number), 1 A.M. (C. 34119). *A. aurantiocinctus*. Holotype (badly broken) T.M. (E. 395/7736). Paratypes 2 N.M.V. (no number), 2 A.M. (C. 39489).

TYPE LOCALITIES. *A. erratica*. 11 km E. of Cape Pillar, S. Tasm., 183m. *A. aurantiocinctus*. Off Thouin Bay, Tasm., 73m.

ADDITIONAL MATERIAL EXAMINED. *Qld:* Albany Passage, 20-25m (4). 3km N.E. of W. side Gillett Cay, Swain Reefs, 64-73m (83). N.E. of Rockhampton, 64m (12). Off Fraser

Is., 59m (4). Off Moreton Bay, 77m, S.E.M. stub no. 127 (7). *N.S.W.:* E. of Cape Byron, 200m (1). Off Broughton Is., Port Stephens, 45m (2). Fingal Bay, Port Stephens (4). *Sydney;* Private water bore at 4m depth, Wetherill St., Narrabeen (2); Collaroy Beach (7); Manly Beach, 2 lots (6); Middle Harbour (2); Off Sow and Pigs Reef, 11-14m (1); Off Chinamans Beach, Middle Harbour, 5m (11); Little Coogee Bay (6); Ocean Beach, Kurnell, Botany Bay (6), Ulladulla (2), 32km S.E. of Twofold Bay, 149m (1). *N. Tasm.:* Bass Strait; Just N. of Waterhouse Is., 36m (1) (T.M.); E. of Flinders Is., 50m (1) (T.M.); E. of King Is., 46m (9), 33m (4), 58-77m, S.E.M. stub no. 124 (9); Elephant Shoal Reef, S.E. of King Is., (sev) (N.M.V.). *E. Tasm.:* Off Piccaninny Pt., N. of Bicheno, 27m (1). Oyster Bay (3) (N.M.V.). Great Oyster Bay, 14m (1). Off Schouten Is. (1) (T.M.). *S. Tasm.:* N.E. of Cape Pillar, 113m (1). Off Port Arthur, 128m (2) (N.M.V.). Derwent Estuary (2) (1 in T.M.). Cape Pillar, 183m, 2 lots (14). 15km N.E. Tasman Is., 570m (1). Tasmania, 2 lots (7). *W. Tasm.:* N.W. of Sandy Cape, 132m (2). W. of West Pt., 80m (5). *Vic.:* Off Wilsons Promontory, 2 lots (8) (N.M.V.). Between Eagle and Crawfish Rocks, N.W. Arm, Western Port, 3-6m, S.E.M. stub no. 124 (5). Western Port (sev) (S.A.M. & N.M.V.). *S.A.:* Off Beachport, 73m, 2 lots (sev); 274m (3) (S.A.M.). Off Cape Jaffa, 90m (2) (S.A.M.). N.W. of Cape Borda, Kangaroo Is., 100m, 2 lots (sev) (S.A.M.). 64km S. of Cape Wiles, 183m (2). 52km S.S.W. of St. Francis Is., 64m (3). Off St. Francis Is., 64m, 2 lots (15) (S.A.M.). Great Australian Bight (S.W. of Eucla), 75m (11). *S.W.A.:* Between Eucla and Esperance, 79-147m (1). E. of Cheyne Bay, 75m (2). *W.A.:* 4-8km off Peppermint Grove Beach, between Bunbury and Busselton, 5-8m (2). Pt. Peron, S. of Fremantle, on exposed S.W. side, 4m (1). S.W. end of Garden Is., off Fremantle (1).

DISTRIBUTION AND HABITAT. N.Qld, S. to Tasm. and W. to mid W.A., on the continental shelf and in the sublittoral (fig. 14).

REMARKS. The types of *E. erratica* and *A. aurantiocinctus* are virtually identical except for colour pattern, and consequently are here considered to represent one species as the colour bands of *A. aurantiocinctus* appear to be developed to varying degrees, or not at all, within specimens from one population. There is, however, a considerable range of shape and size amongst the material examined and it is possible that more than one species is represented, although this cannot be adequately demonstrated with the material at hand which mostly consists of small samples of dead shells. For example shallow-water specimens from N.S.W. are known only from shells and may possibly represent a separate species as they are consistently slightly smaller and never seem to develop the orange rings seen in the deeper-water populations. Specimens from Queensland tend to be small and have a more strongly retracted outer lip and more sharply angled base than most southern material.

This species is placed in *Crassitoniella* on the basis of the operculum and the central tooth of the radula of the Recent sub-species, which closely resemble those of *C. flammea*. The lateral and inner marginal teeth have relatively smaller cusps and the teleoconch features are rather atypical. *Eatoniella (Albitoniella) thola* Ponder, 1965, from northern New Zealand has similar shell features to those of *C. erratica erratica* and probably also belongs in *Crassitoniella*.

This species differs from *C. flammea* and other Australian members of the family in its moderately large shell, evenly conical spire and the slightly reflected edge of the outer lip which has a weak to moderate varix behind.

Gatliff and Gabriel's (1914) record of *Rissoa erratica* from off Wilsons Promontory, Vic. is a misidentification of *"Cithna" angulata* Hedley.

Crassitoniella erratica subbicolor (Ludbrook, 1956). Fig. 4f.

Amphithalamus (Pisinna) subbicolor Ludbrook, 1956:27, pl. 2, fig. 10.

SHELL: very similar to *C. erratica* except that the periphery is more acutely angled and sometimes sharp (fig. 4f).

Dimensions	Length	Diameter
Holotype	2.30 mm	1.30 mm
Balcombe Bay, Mornington, Vic.	1.66	1.10

TYPES. Holotype Tate Mus. coll., Univ. of Adelaide (F15151). 10 paratypes are cited in the original description from the type locality and 29 from 2 other localities.

TYPE LOCALITY. Abattoirs Bore, Adelaide (holotype and 10 paratypes), Hindmarsh Bore, Adelaide (23 paratypes), Weymouth's Bore, Adelaide (6 paratypes). All Dry Creek Sands, Upper Pliocene, S.A.

ADDITIONAL MATERIAL EXAMINED. *Upper Pliocene:* Dry Creek Sands; Hindmarsh Bore, 450-487 feet, Adelaide (3) (S.A.M.D.). Dry Creek Sands, Cowandilla Bore, 525 feet, Adelaide (1) (S.A.M.D.). *Miocene:* Muddy Creek Marl; Clifton Bank, Muddy Creek, Hamilton, Vic., Chapman Coll. (N.M.V.). Balcombe Clay; Fossil Beach, Balcombe Bay, Mornington, Vic., Parr Coll. (2) (N.M.V., 2 lots). *Lower Miocene:* Freestone Cove Sandstone (=lower bed); Table Cape (=Fossil Bluff), N. Tasm., Parr Coll. (3) (N.M.V.). Table Cape (=Fossil Bluff), N. Tasm., 1915, coll. E.D. Atkinson (2).

RANGE AND DISTRIBUTION. Lower Miocene to Upper Pliocene, N. Tasm., Vic. and S.A. (fig. 14).

REMARKS. This sub-species is here considered to be the ancestor of *C. erratica erratica*. The degree of angulation of the periphery is variable in the material examined but the fossil material is consistent in having a more sharply angled periphery than most Recent specimens. The holotype is less sharply angled than most of the other fossil material examined (and is also younger in age), and the most acutely angled material (although not the oldest) is from Balcombe Bay (Miocene). Most of Ludbrook's non paratype material identified by her as this species consists of *Notoscrobs (Microfossa)* sp., but the paratype series has not been examined.

Crassitoniella flammea (Frauenfeld, 1867). Figs 4g, h; 10l-q.

Sabanaea flammea Frauenfeld, 1867:12, pl. 2, fig. 18.

Sabinaea flaminea (sic) "Dunker". — Angas, 1877:187.

Rissoa (Setia) flamia Beddome, 1882:169, No. 16.

Rissoa flammea. —Weinkauff, 1885:184, pl. 24, fig. 9; Pritchard and Gatliff, 1906:63.

Rissoia (Sabanaea) flammea. — Tryon, 1887:339, pl. 63, fig. 64.

Rissoia (Setia) flamia. — Tryon, 1887:359; Brazier, 1895:697.

Rissoia (Setia) sophiae Henn and Brazier, 1894:174.

Rissoia (Sabanaea) flammea. — Tate, 1899:232.

Rissoia (Setia) beddomei Tate, 1899:234 (nom. nov. pro *flamia* Beddome, non *flammea* Frauenfeld or Pease. Unnecessary name change).

Rissoia beddomei. — Tate and May, 1901:393, pl. 26, fig. 64.

Rissoa sophiae. — Pritchard and Gatliff, 1902:106.

Amphithalamus flammeus. — Hedley, 1911:106.

Estea flammea. — Hedley, 1918:M. 53; Laseron, 1950:273.

Dardanula flammea. — May, 1921:50; May, 1923, pl. 23, fig. 29; Cotton, 1944:306.

Crassitoniella flammea. — Ponder, 1965:93, pl. 10, fig. 1.

SHELL: minute, solid, conical, orange-red, often with white streaks. Protoconch of 1½ whorls, orange; teleoconch of 3¼-3⅓ almost flat whorls; periphery rounded to subangled, base rather flattened. Aperture with slightly thickened lips; inner lip considerably separated from base abapically; outer lip evenly retracted, sometimes with a trace of a weak varix behind. Colour orange-red to white, often with orange or white irregular axial streaks; columella and edge of aperture usually yellowish-white (figs 4g, h; 10l-m, o-p).

Dimensions	Length	Diameter	
Syntype	2 mm	1.25 mm	(from original description)
Figured specimens (S.E.M.)			
(N. Stradbroke Is., Qld)	2.06	1.20	
	1.90	-	
(Balmoral, N.S.W.)	2.00	1.30	
	1.92	-	

OPERCULUM: transparent, yellow (fig. 10n).

RADULA: central teeth with 2 short basal projections on either side of two very short knob-like projections on a mid-basal tongue-like extension; cusps 1 + 1 + 1, median cusp very large, spade-like, lateral cusps small; lateral teeth 1 + 1 + 1, inner marginal teeth 1 + 1 (1-2), two inner cusps large and broad; outer marginal teeth relatively small with about 4 small cusps (fig. 10q).

Opercula and radulae examined from N. Stradbroke Is., Qld (S.E.M. stub no. 213) and Balmoral, Sydney. N.S.W. (S.E.M. stub no. 97).

ANIMAL: head-foot with orange head and opercular lobes, remainder whitish; no opercular tentacles (Sydney).

TYPES. *Sabanaea flammea.* Syntypes (10 and 4 ex. Mohrenstern Coll.) Naturhistorisches Museum, Vienna. *Rissoa flamia.* Lost? *Rissoia sophiae.* Lost?

TYPE LOCALITIES. *S. flammea.* Botany Bay, N.S.W. *R. flamia.* 13m, Blackmans Bay, Tasm. *R. sophiae.* Watsons Bay, Sydney, N.S.W.

ADDITIONAL MATERIAL EXAMINED. *S. Qld:* Caloundra (4). Moreton Bay (28). *N. Stradbroke Is.;* Off Flat Rock, on algae, 24-30m, S.E.M. stub no. 213 (31), on algae, 21-27m (26); Shag Rock, on algae, 4-9m (3). *N.S.W.:* Woody Head, near Iluka (4). Woolgoolga (1). North Beach, Bellingen River (2). S. side of Fish Rock, 3km E. of Smoky Cape, on algae, 18m (1). Hallidays Pt., on algae, 2 lots (71). *Port Stephens:* Off Broughton Is., 64m (1); Fingal Bay (60); Little Beach (16); Off Port Stephens, 73m (1); Fishermans Bay, S. of Port Stephens (10). Off Patonga Beach, Broken Bay (3). Pittwater (1). *Sydney;* Narrabeen (sev); Private water bore at 4m depth, Wetherill St., Narrabeen (1); Long Reef, Collaroy, 3 lots (36); Manly Beach (2); North Harbour (11); S.E. side of Reef Beach, North Harbour (16); Forty Baskets Beach (8); Fairlight, (2), on coralline algae, low tide, 2 lots (16), on short algae (55); Balmoral, on brown algae (6), 18m (4), Sow and Pigs Reef, 5 lots (sev); Off

Chinamans Beach, Middle Harbour (3); Shark Is. (100); Bottle and Glass Rocks, 3 lots (60); Little Coogee Bay, 5 lots (155); Kurnell, Botany Bay, 2 lots (110); Cronulla Beach, 2 lots (4); Gunnamatta Bay, Port Hacking (7). Shellharbour, on algae (1). Bass Pt., on brown algae, 20m (25). Werri Beach (25). Currarong (14). Honeymoon Beach, Jervis Bay, under stones, low tide (33). Ulladulla (35). S. side Ulladulla, on small brown algae, low tide, 2 lots (45), on coralline algae (20). Wimbie Beach, Batemans Bay, on large brown algae (24), on coralline algae (22). Batehaven, Batemans Bay, on medium brown algae, mid-tide (10). Bittangabee, N. side of Green Cape, on coralline algae, in sheltered pool (24). Eden Harbour (12). S. side of Green Cape, 10m (1). *N. Tasm:* Bass Strait; Deal Is., on algae, 6m (4); Murray Pass., Deal Is., on red algae, 30-50m (sev); East Cove, Deal Is., 6-15m (sev); Little Squally Cove, Deal Is., on algae, 10-30m (15); Just N. of Waterhouse Is., 36-40m, 3 lots (sev) (T.M.); Elephant Shoal Reef, S.E. of King Is. (sev) (N.M.V.). *E. Tasm.:* Green Cape, Maria Is., on algae, 6m (57). *S. Tasm.:* Pirates Bay, Eaglehawk Neck, on intertidal rocks, low tide (1). *Vic.:* S.E. of Gabo Is., on algae, 28m (14). E.S.E. of Gabo Is., on algae, 15-18m (18). Between Eagle and Crawfish Rocks, N. W. Arm, Western Port, 3-6m (1). Port Fairy (3).

DISTRIBUTION AND HABITAT. Southern Qld. to Vic. and Tasm., on algae in the lower littoral and sublittoral (fig 14), often abundant.

REMARKS. The type species of *Crassitoniella, C. carinata,* from northern New Zealand, closely resembles *C. flammea* but has a weak peripheral cord and is always uniform orange in colour. No Australian species can be confused with *C. flammea,* its distinctive heavy, blunt-spired shell and characteristic coloration make it easily recognisable.

Although the types of *R. sophiae* Henn and Brazier and *R. flamia* Beddome have not been located, there are specimens in the Australian Museum (that may be parts of the type series) which were obtained from the authors and bear their species names. Pritchard and Gatliff (1902) discuss the confusion surrounding these names in detail.

Cotton's (1953) record of *Dardanula flammea* from Arno Bay, S.A. is based on 2 rather worn specimens of what is possibly a new species of *Eatoniella* belonging to the subgenus *Pellax* Finlay, 1927, of which there is insufficient material to describe herein.

A LIST OF THE KNOWN SPECIES OF THE EATONIELLIDAE WITH THE EXCEPTION OF THE SPECIES FROM THE NEW ZEALAND REGION

This list, probably very incomplete, is largely the result of the personal examination of original material of as many suspected members of the family as possible. A few additional species have been included on the basis of published information on their radulae and opercula. The New Zealand species of this family have been monographed by Ponder (1965).

The type localities are given along with the original reference and the location of the type or other material from which the species' familial position was determined. A generic determination is also given for each species.

Several species described by Turton (1932) from Port Alfred, South Africa, are probably additional species of the Eatoniellidae but his type material has not been examined and his descriptions and figures are inadequate for accurate familial determination.

algoensis Thiele, 1925:78. *Rissoa.* "Valdivia" stations 81, 95 and 101, South Africa (types: H.U.M.). *Eatoniella (Eatoniella).*

argentinense Castellanos and Fernández, 1972:6. *Eatoniella*. Punta Loma, Golfo Nuevo, Argentina. *Eatoniella (Eatoniella)*.

australis Watson, 1886:608. *Rissoa (Setia)*. Kerguelen Island (type: B.M.N.H.). *Eatoniella (Eatoniella)*.

caliginosa Smith, 1875:71. *Eatonia*. Swains Bay, Kerguelen Island (type: B.M.N.H. 2 lots of syntypes). *Eatoniella (Eatoniella)*.

capensis Thiele, 1912:278. *Eatoniella*. Simons Bay, South Africa (type: H.U.M.). *Eatoniella (Eatoniella)*.

duperrei Vélain, 1877:115. *Paludestrina*. Isle St. Paul (type: P.M.). *Eatoniella (Eatoniella)*.

georgiana Martens and Pfeffer, 1886:97. *Skenella*. South Georgia (types not examined). *Skenella*, type of genus.

georgiana Martens and Pfeffer, 1886:92. *Rissoa*. South Georgia (type: H.U.M, 2 specimens, not marked types). *Eatoniella (Albosabula)?*

glacialis Smith, 1907:9, *Rissoia*. Discovery Winter Quarters, Antarctica, 25-127 fathoms (45-232m). *Eatoniella (Eatoniella)*, fide Arnaud, 1972:118.

helga Bartsch, 1915:133. *Microsetia*. Port Alfred, South Africa (type: U.S.N.M.). *Eatoniella?*

hyalina Thiele, 1912:236. *Eatoniella*. Observatory Bay, Kerguelen Island (type: H.U.M., destroyed but one other lot labelled as this species also in H.U.M.). *Eatoniella (Eatoniella)*.

ignota Thiele, 1925:78. *Rissoa*. "Valdivia" station 101, South Africa (Algoa Bay) (types: H.U.M.). *Eatoniella (Eatoniella)*.

inflata Dall, 1876:43. *Eatoniella*. Kerguelen Island (type not examined, U.S.N.M.). Probably a synonym of *E. kerguelenensis* (fide Arnaud, 1972:118).

japonica Thiele, 1925:88. *Eatoniella*. Kobe, Japan (type: H.U.M., in poor condition, holotype only). *Eatoniella?*

kerguelenensis Smith, 1875:70. *Eatonia*. Kerguelen Island (types: B.M.N.H.,many syntypes). *Eatoniella (Eatoniella)*, type of genus. (The "subspecies" *confusa* Strebel, 1908:58 and *major* Strebel, 1908:57 are probably typical *Eatoniella* but authentic material has not been examined. Both forms are from South Georgia).

latina Marincovich, 1973:26. *Eatoniella (Eatoniella)*. Iquique, Chile, lower littoral (paratypes, A.M.). *Eatoniella (Eatoniella)*.

nigra Krauss, 1948:86. *Rissoa*. South Africa (specimens examined ex Krauss in H.U.M.). Radula and operculum Barnard, 1963:190, fig. 36. *Eatoniella (Eatoniella)*.

pellucida Preston, 1905:5. *Rissoina*. Ceylon (=Sri Lanka) (types: B.M.N.H. Holotype and 2 paratypes; 2 paratypes A.M.). *Eatoniella*. Not *Eatoniella (Albosabula) pellucida* (Tate and May, 1900). A replacement name is here given: *Eatoniella (Eatoniella) prestoni* nom. nov.

regularis Smith, 1915:65. *Rissoia*. Off Cape Adare, Antarctica, 45-50 fathoms (82-91m) (types: B.M.N.H., 3 syntypes). *Eatoniella (Eatoniella)*. Very similar, if not identical to *E. kerguelenensis*.

subgonostoma Strebel, 1908:59. *Eatoniella*. Port Louis, South Georgia, on algae. Not examined but illustration appears to represent a typical *Eatoniella (Eatoniella)*.

subrufescens Smith, 1875:71. *Eatonia*. Kerguelen Island (4 specimens ex. Smith, Royal Scottish Museum, radula and operculum examined). *Eatoniella (Eatoniella)*.

thalia Bartsch, 1915:126. *Sabanaea*. Port Alfred, South Africa (type: U.S.N.M.). *Eatoniella (Eatoniella)*.

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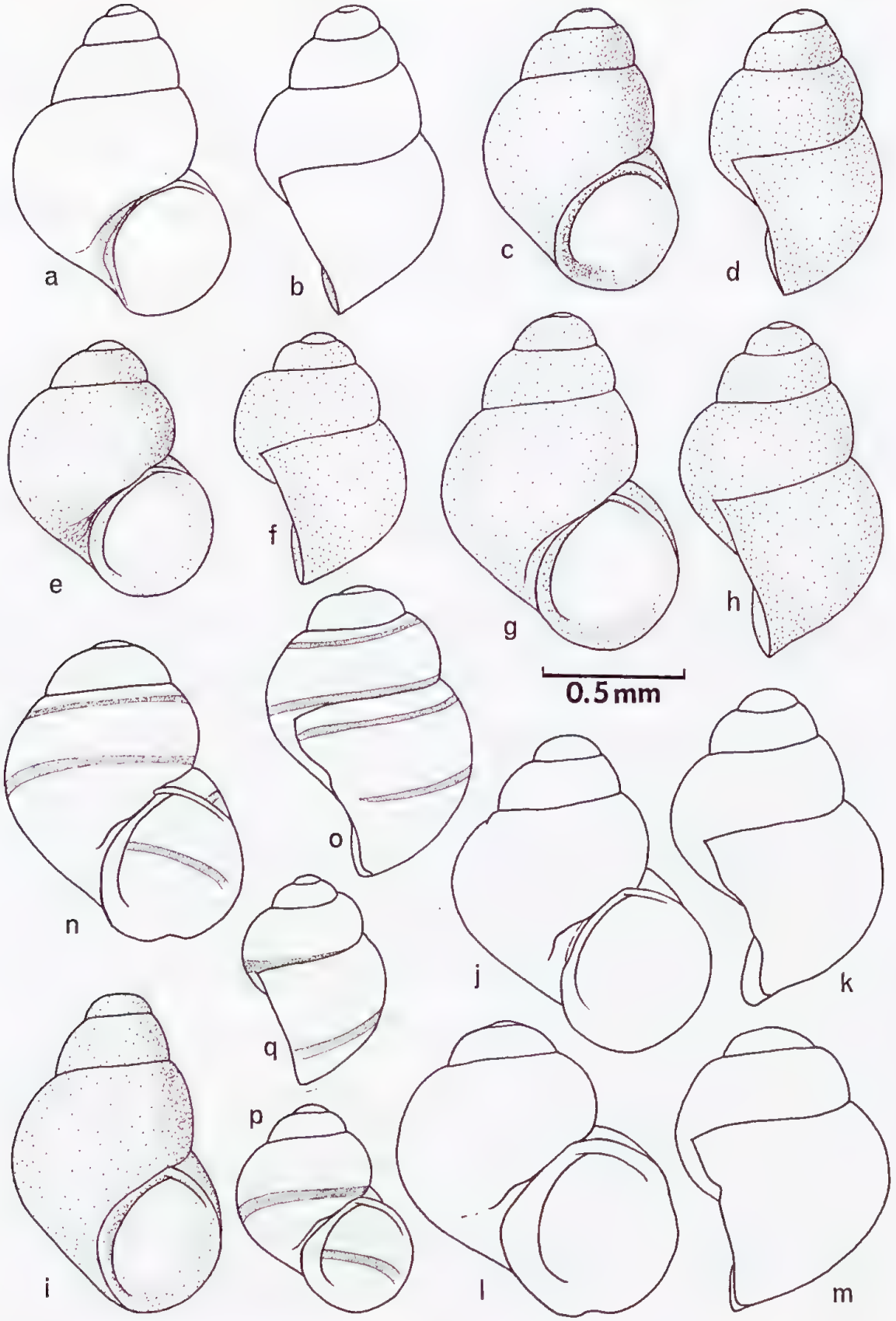

Fig 1. a-b; *Eatoniella (E.) ansonae* sp. nov., holotype, off Dunsborough, S.W.A. c-i; *E. (E.) atropurpurea* (Frauenfeld), c-d; paratype of *Notosetia purpureostoma* May, Penguin, Tas., e-f; lectotype of *Notosetia fusca* Laseron, North Harbour, Sydney, N.S.W., g-h; lectotype of *Notosetia aethiopia* Laseron, North Harbour, Sydney, N.S.W. i; syntype, Sydney, N.S.W. (traced from Polaroid photograph). j-k; *E. (E.) shepherdi* sp. nov., holotype, East Cove, Deal Is., N. Tasm. l-m; *E. (E.) depressa* sp. nov., holotype, Moonlight Beach, W. of Cape Otway, Vic. n-o; *E. (E.) puniceolinea* sp. nov., holotype, South Pt., S. of Two Peoples Bay, Albany, S.W.A. p-q; *E. (E.) howensis* sp. nov., holotype, Lord Howe Is. (See text for dimensions).

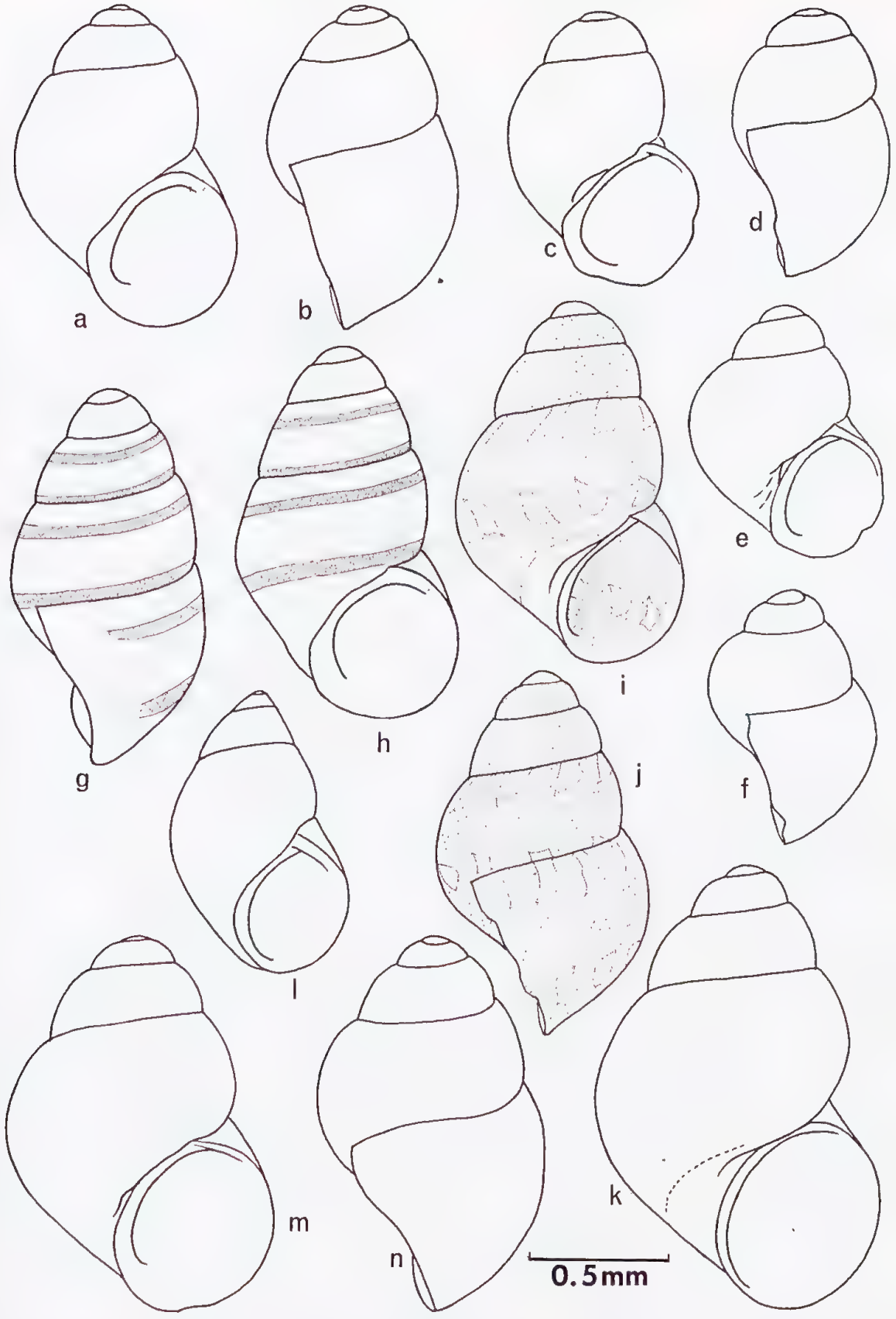

Fig. 2. a-b; *Eatoniella (E.) juliae* sp. nov., holotype, near Hopetoun Jetty, S.W.A. c-d; *E. (E.) exigua* sp. nov., holotype, S. end of Green Cape, N.S.W. e-f; *E. (E.) talboti* sp. nov., holotype, One Tree Is., Capricorn Group, Qld. g-h; *E. (E.) hewittae* sp. nov., holotype, Cape Naturaliste, S.W.A. i-k; *E. (E.) australiensis* (Thiele); i-j; holotype of *Lucidestea maculosa* Laseron, Lindeman Is., Qld. k; holotype, Cockburn Sound, W.A. (traced from Polaroid photograph). l; *E. (Albosabula) pellucida* (Tate & May), holotype, Frederick Henry Bay, S. Tasm. (traced from Polaroid photograph). m-n; *E. (E.) galbinia* (Laseron), lectotype, North Harbour, Sydney, N.S.W. (See text for dimensions).

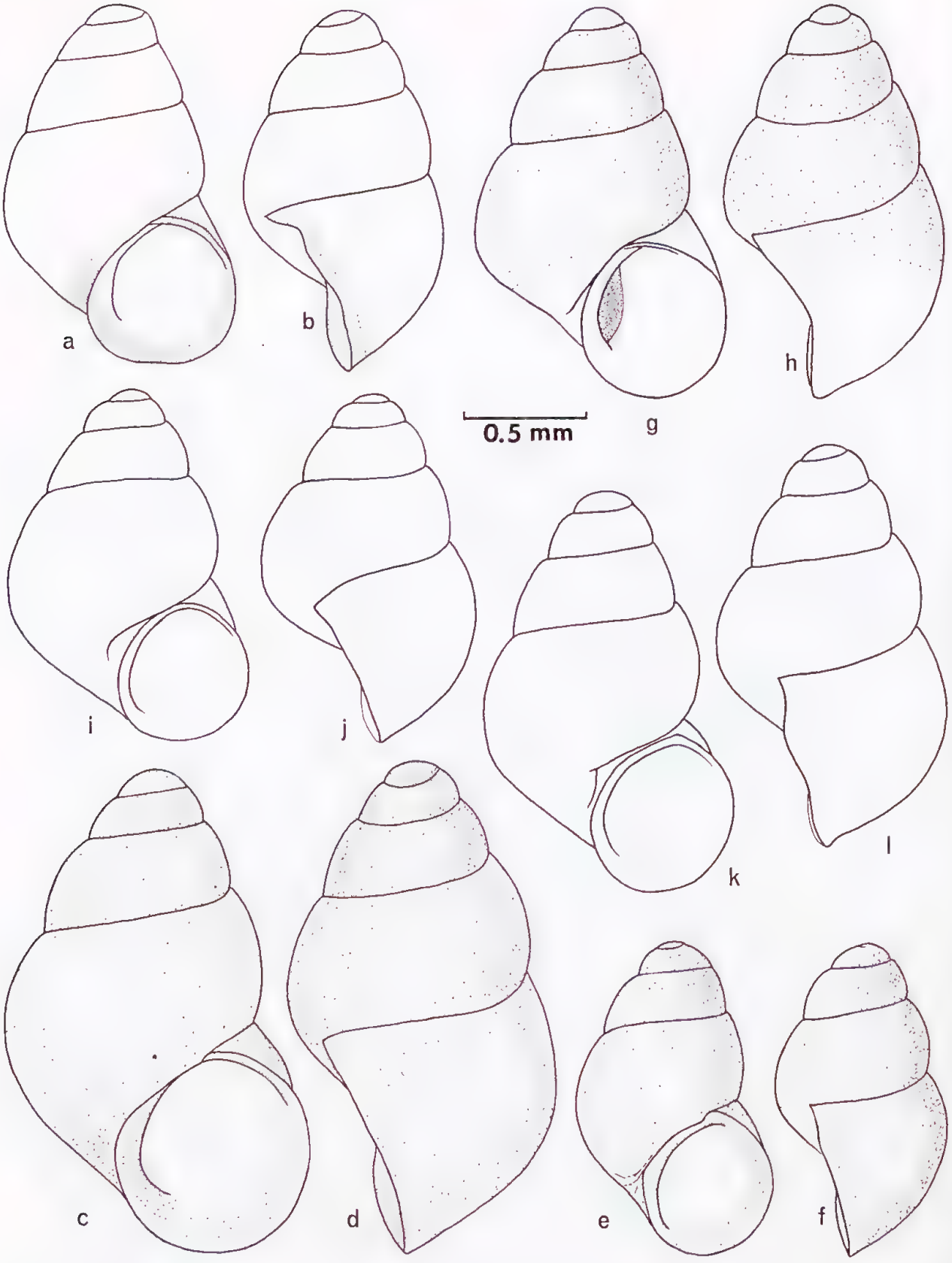

Fig. 3 a-d; *Eatoniella (E.) melanochroma* (Tate), a-b; Yallingup, S.W.A., c-d; Pirates Bay, Eaglehawk Neck, S. Tasm. e-f; *E. (E.) atrella* sp. nov., holotype, N. side of Black Head, Nadgee, N.S.W. g-h; *E. (E.) fulva* sp. nov., holotype, South Pt., S. of Two Peoples Bay, Albany, S.W.A. i-j; *E. (E.) victoriae* sp. nov., holotype, N.W. Arm, Western Port, Vic. k-l; *E. (E.) taylorae* sp. nov., holotype, Elliston, S.A. (See text for dimensions).

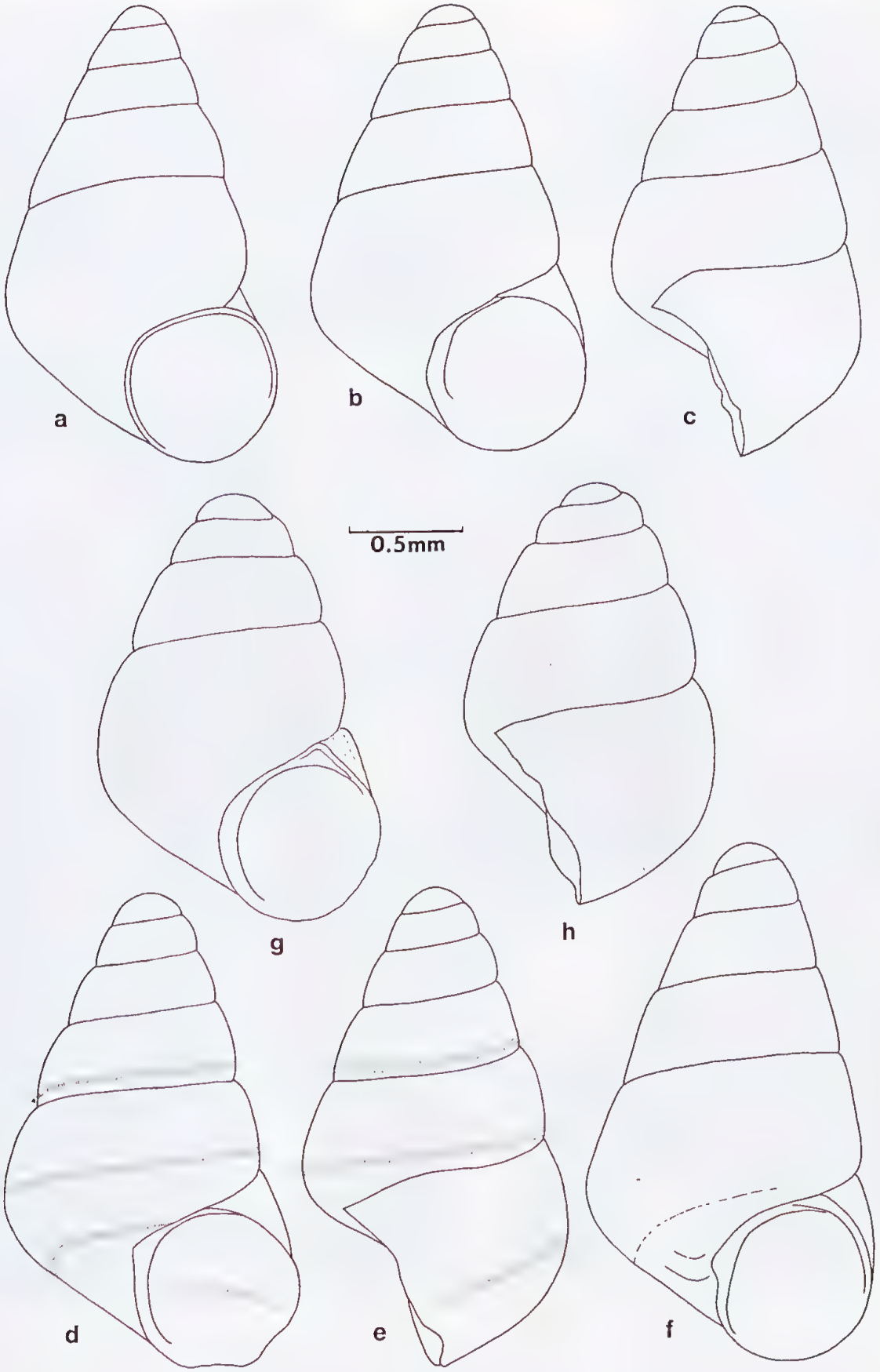

Fig. 4. a-e; *Crassitoniella erratica erratica* (May), a; holotype, off Cape Pillar, S. Tasm., b-c; topotype. d-e; paratype of *Amphithalamus aurantiocinctus* May, Thouin Bay, Tasm. f; *C. erratica subbicolor* (Ludbrook), holotype, Abbattoirs Bore, Adelaide, S.A. g-h; *C. flammea* (Frauenfeld), topotype, Botany Bay, Sydney, N.S.W. (See text for dimensions).

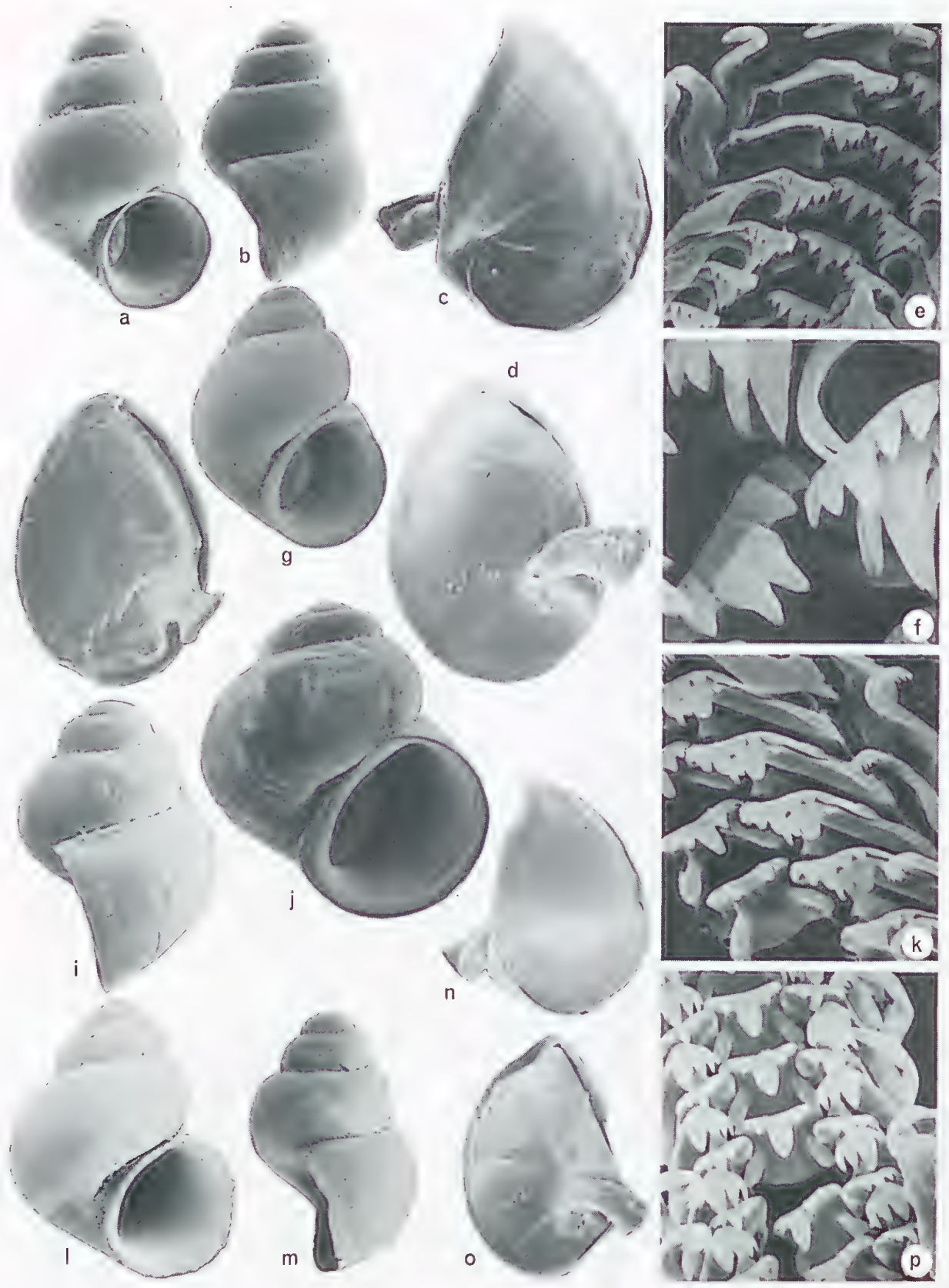

Fig. 5. a-f; *Eatoniella (E.) ansonae* sp. nov., a-b; shell (front and side view) X50, c-d; operculum (outer and inner side) X180, e-f; radula (e. X1400, f. X4800), off Dunsborough, S.W.A., paratypes, S.E.M. stub no. 129. g-k; *E. (E.) atropurpurea* (Frauenfeld), g; shell (front view) X50, h; operculum (inner side) X 140, Forster, N.S.W., S.E.M. stub no. 104, i; shell (side view) X 60, Nambucca Heads, N.S.W., S.E.M. stub no. 96, j; shell (front view) X 80, k; radula, X 1800, Pt. Lookout, N. Stradbroke Is., Qld., S.E.M. stub no. 190. l-p; *E. (E.) shepherdi* sp. nov., l-m; shell (front and side view) X 70, n-o; operculum (outer and inner side) X 100, p; radula, X 1400, Deal Is., Bass Strait, N. Tasm. S.E.M. stub no. 101.

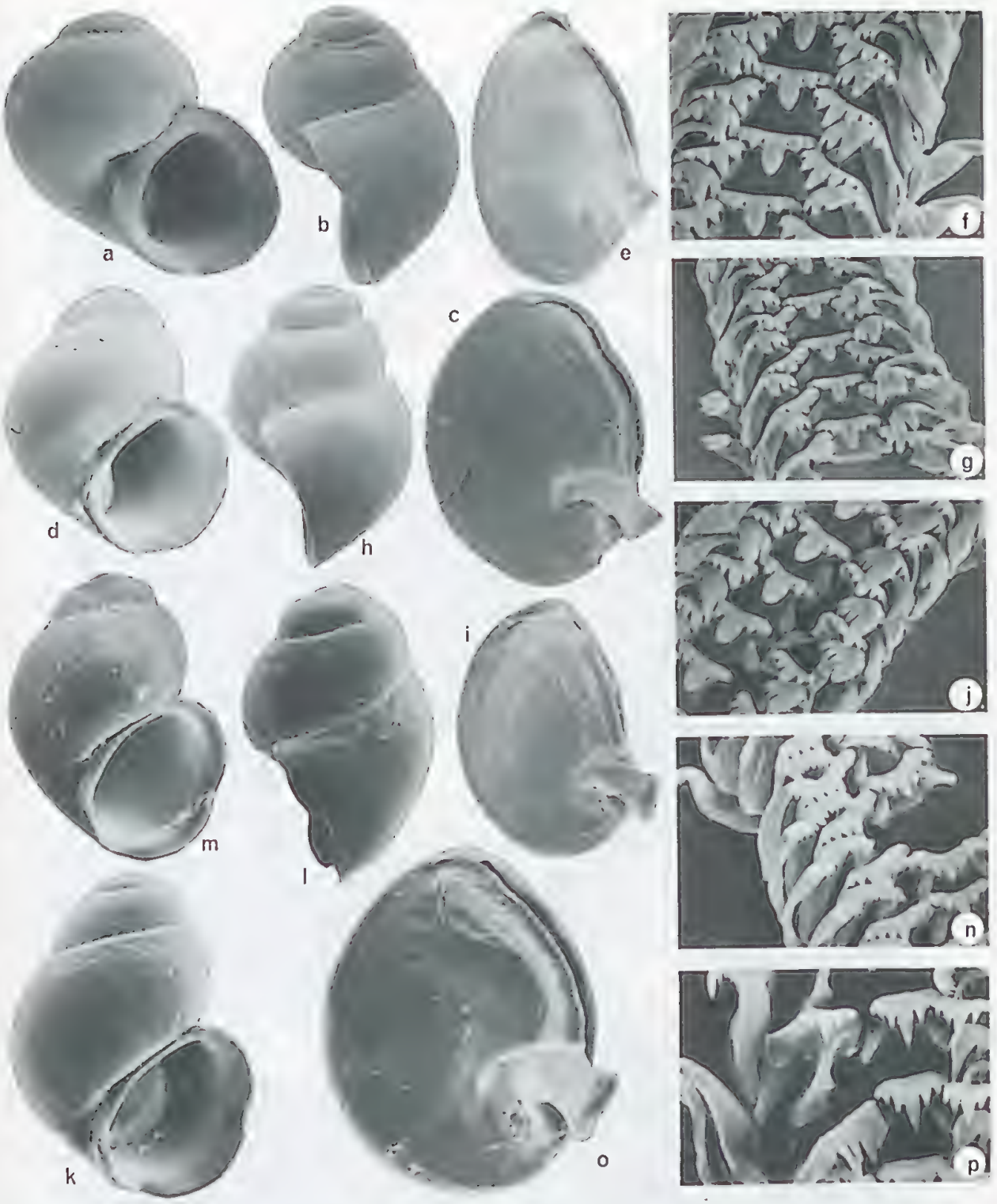

Fig. 6. a-c; *Eatoniella (E.) depressa* sp. nov., a-b; shell (front and side view) X 45, c; operculum (inner side) X 110; Moonlight Beach, W. of Cape Otway, Vic., S.E.M. stub no. 99. d-j; *E. (E.) puniceolinea* sp. nov., d; shell (front view) X 45, e; operculum (inner side) X 100, f-g; radula (f. X 1400, g. X 900), Deal Is., Bass Strait, N. Tasm. S.E.M. stub no. 108, h; shell (side view) X 45, i; operculum (inner side) X 110, j; radula, X 900, Carnac Is., off Fremantle, W.A., S.E.M. stub no. 105 (figs h-j; *E. (E.)* cf. *puniceolinea).* k-n; *E. (E.) exigua* sp. nov., k-l; shell (front and side view) X 60, Green Cape, N.S.W., S.E.M. stub no. 265, m; shell (front view) X 60, n; radula, X 1700, Deal Is., Bass Strait, N. Tasm., S.E.M. stub no. 128. o-p; *E. (E.) talboti,* sp. nov., o; operculum (inner side) X 170, p; radula, X 1500, One Tree Is., Capricorn Group, Qld, S.E.M. stub no. 262.

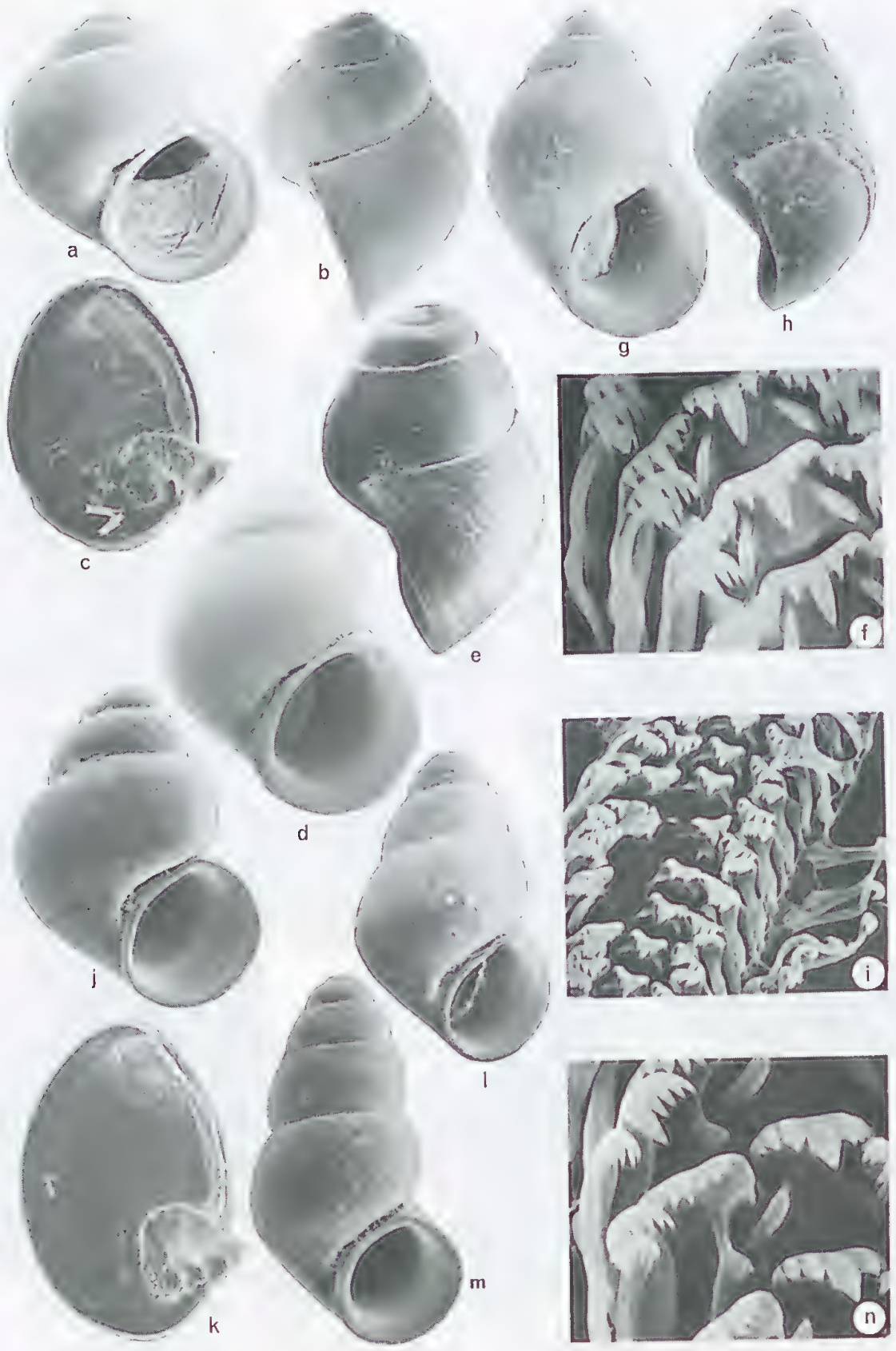

Fig. 7. a-c; *Eatoniella (E.) howensis* sp. nov., a-b; shell (front and side view) X 80, c; operculum (inner side) X 190, off Phillip Pt., Lord Howe Is., S.E.M. stub no. 106. d-f; *E. (E.) juliae* sp. nov., d-e; shell (front and side view) X 55, f; radula, X 2160, Hopetoun Jetty, S.W.A., S.E.M. stub nos. 234, 507. g-i; *(Albosabula) pellucida* (Tate & May), g-h; shell (front and side view) X 55, i; radula, X 1650, Eaglehawk Neck, S. Tasm., S.E.M. stub no. 125. j-l; *E. (E.) australiensis* (Thiele), j; shell (front view) X 45, k; operculum (inner side) X130, Garden Is., W.A., S.E.M. stub no. 136, l; shell (front view) X 55. Exmouth, W.A., S.E.M. stub no. 98. m-n; *E. (E.) hewittae* sp. nov., m; shell (front view) X 55, n; radula, X 2160; Carnac Is., off Fremantle, W.A., S.E.M. stub no. 246.

Fig. 8. a-e; *Eatoniella (E.) fulva* sp. nov., a-b; shell (front and side view) X 45, c; operculum (inner side) X 120, Deal Is., Bass Strait, N. Tasm., S.E.M. stub no. 109, d; shell (front view) X 50, e; radula, X 1600, Hopetoun Jetty, ws.w.a., s.e.m. stub no. 182. f-n; *E. (E.) galbinia* (Laseron), f-g; shell (front and side view) X 50, North Harbour, N.S.W., S.E.M. stub no. 153, h; shell (front view), X 45, i; radula, X 1500, Pt. Hicks, Vic., S.E.M. stub no. 126, j-k; shell (front and side view) X 50, l; operculum (inner side) X 120, Fairlight, Sydney, N.S.W., S.E.M. stub no. 102, m; shell (front view) X 50, n; operculum (inner side) X 140, Moonlight Beach, W. of Cape Otway, Vic., S.E.M. stub no. 100.

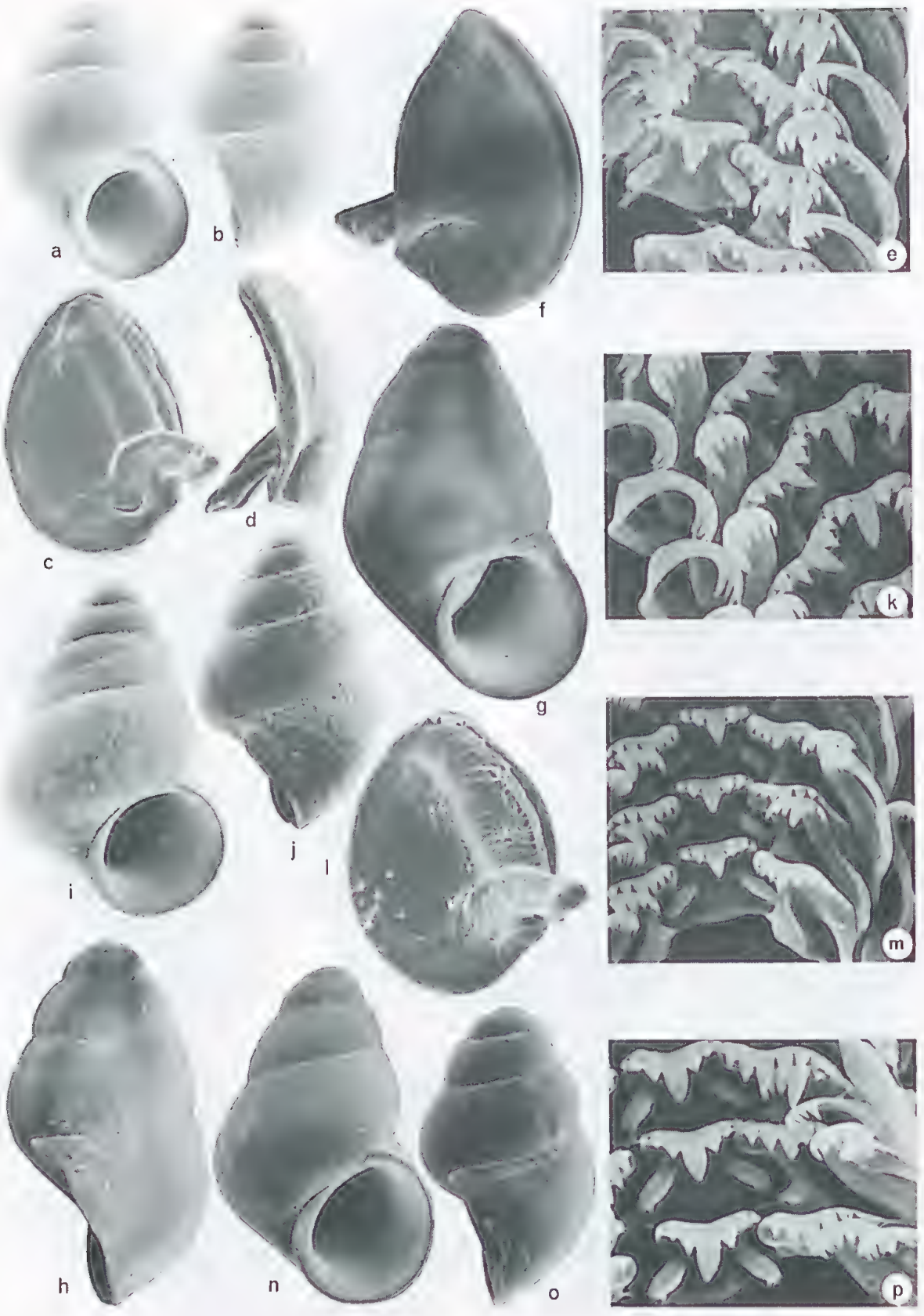

Fig. 9. a-m; *Eatoniella (E.) melanochroma* (Tate), a-b; shell (front and side view) X 30, c-d; operculum (inner and side view) X 100, e; radula, X 1400, Honeysuckle Pt., Shoreham, Vic., S.E.M. stub nos. 82, 95. f; operculum (outer side) X 100, Frederick Henry Bay, S. Tasm., S.E.M. stub no. 33, g-h; shell (front and side view) X 50, Yallingup, S.W.A., S.E.M. stub no. 235, i-j; shell (front and side view) X 35, k; radula, X 1750, Hopetoun Jetty, S.W.A., S.E.M. stub no. 236, l; operculum (inner side) X 120, m; radula, X 1400, Elliston Bay, S.A., S.E.M. stub no. 123. n-p; *E. (E.) atrella* sp. nov., n-o; shell (front and side view) X 50, p; radula, X 2000, Nadgee, N.S.W., S.E.M. stub nos. 238, 265.

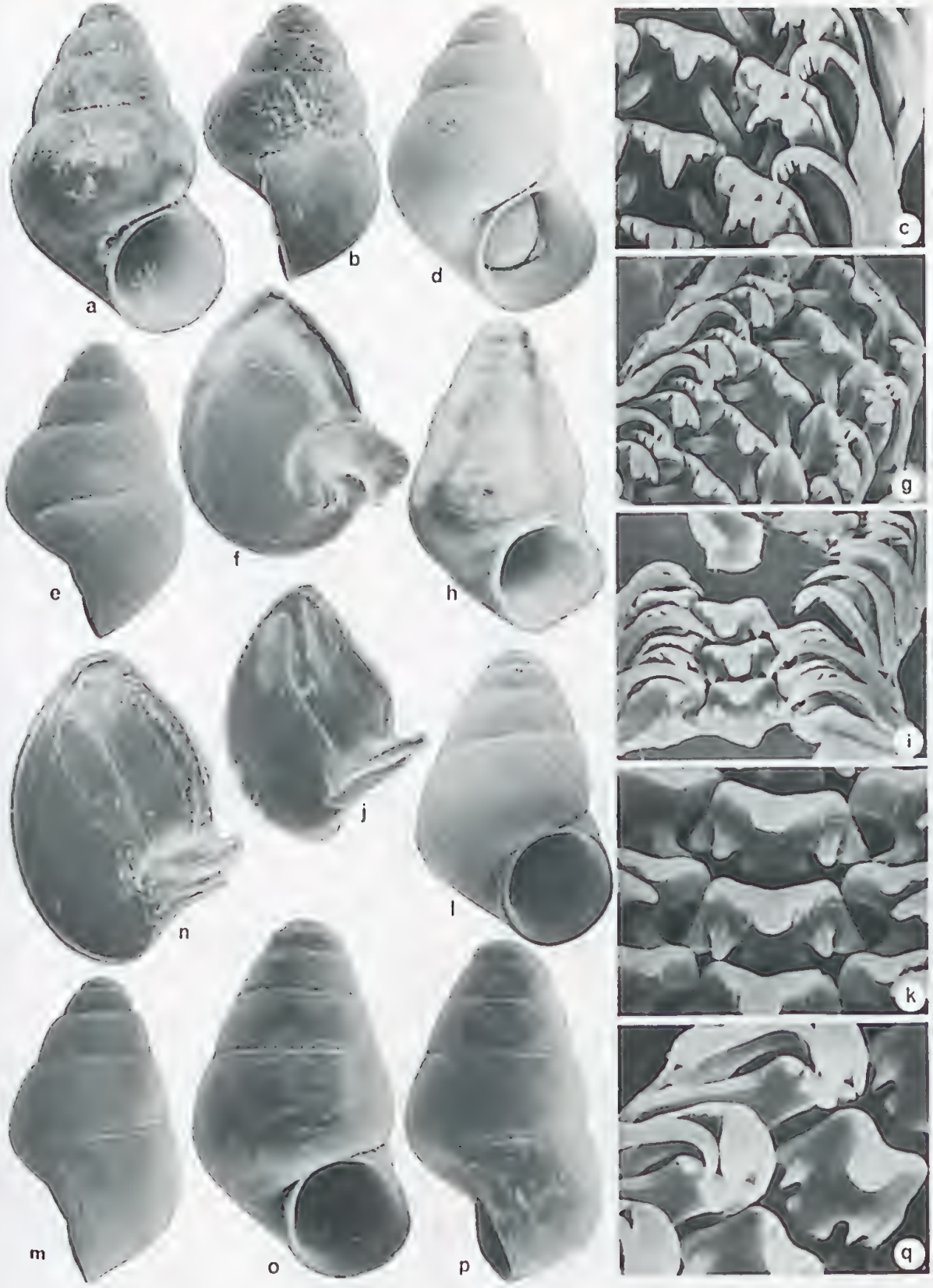

Fig. 10 a-c; *Eatoniella (E.) taylorae* sp. nov., a-b; shell (front and side view) X 35, c; radula, X 2400, Elliston, S.A., S.E.M. stub nos. 237, 266. d-g; *E. (E.) victoriae* sp. nov., d-e; shell (front and side view) X 50, f; operculum (inner side) X 120, g; radula, X 1200, N.W. Arm, Western Port, Vic., S.E.M. stub no. 110. h-k; *Crassitoniella erratica erratica* (May), h; shell (front view) X 30, i; radula, X 950, N.W. Arm, Western Port, Vic., S.E.M. stub no. 124, j; operculum (inner side) X 70, k; radula, X 1750, off Moreton Bay, Qld, S.E.M. stub no. 127. l-q; *C. flammea* (Frauenfeld), l-m; shell (front and side view) X 30, n; operculum (inner side) X 100, Balmoral, Sydney, N.S.W., S.E.M. stub no. 97, o-p; shell (front and side view) X 35, q; radula, X 1750, N. Stradbroke Is., Qld, S.E.M. stub no. 213.

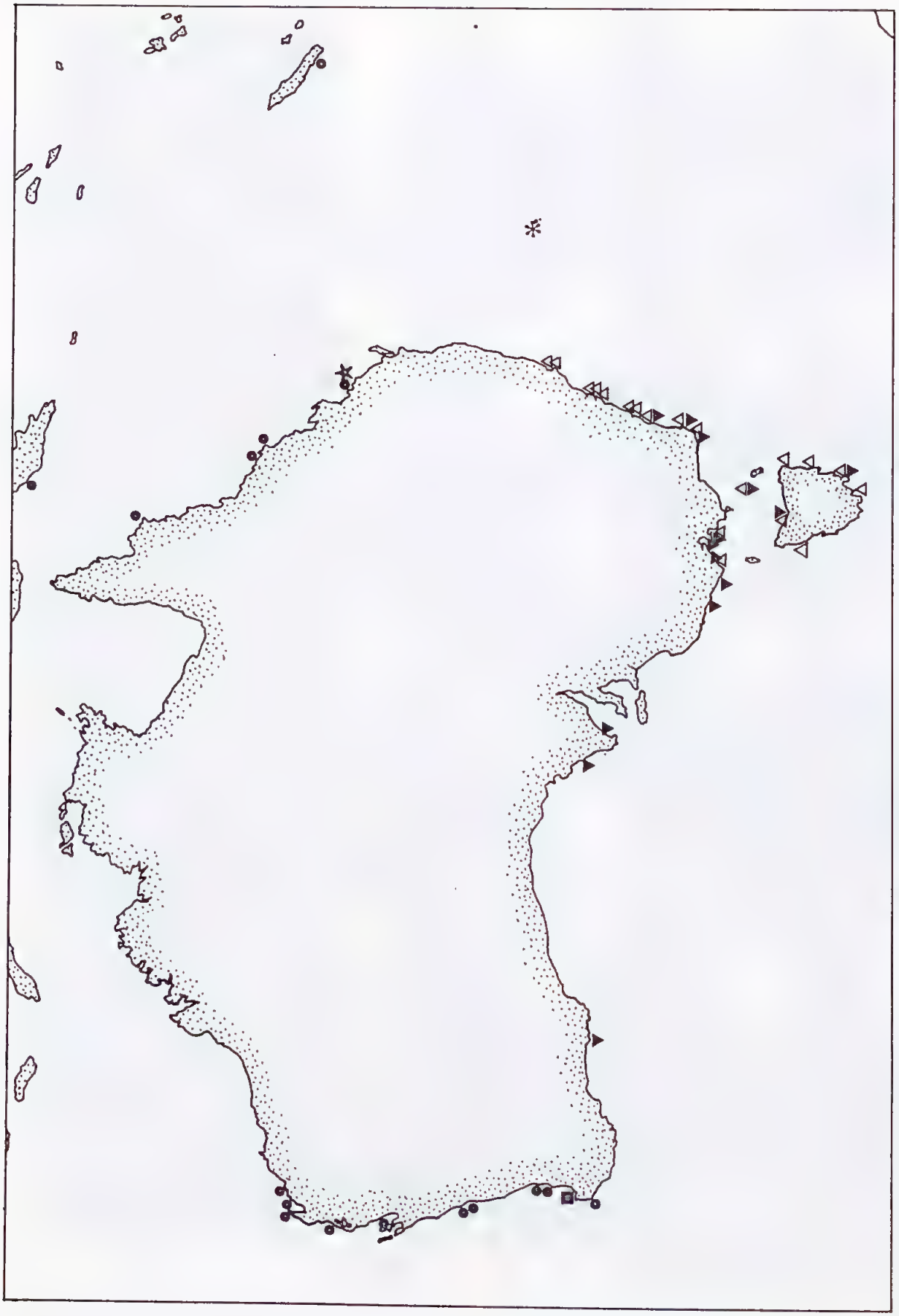

Fig. 11. Distribution of *Eatoniella* species. ■ *Eatoniella (Eatoniella) ansonae* sp. nov., ● *Eatoniella (Eatoniella) australiensis* (Thiele), ★ *Eatoniella (Eatoniella) talboti* sp. nov., ▼ *Eatoniella (Eatoniella) depressa* sp. nov., △ *Eatoniella (Eatoniella) galbinia* (Laseron), **Eatoniella (Eatoniella) howensis* sp. nov.

Fig. 12. Distribution of *Eatoniella* species. ▼ *Eatoniella (Eatoniella) atrella* sp. nov., □ *Eatoniella (Eatoniella) exigua* sp. nov., △ *Eatoniella (Eatoniella) fulva* sp. nov., * *Eatoniella (Eatoniella) juliae* sp. nov., ● *Eatoniella (Eatoniella) melanochroma* (Tate).

Fig. 13. Distribution of *Eatoniella* species. ● *Eatoniella (Eatoniella) atropurpurea* (Frauenfeld), ▽ *Eatoniella (Eatoniella) puniceolinea* sp. nov., ■ *Eatoniella (Eatoniella) shepherdi* sp. nov., ▲ *Eatoniella (Eatoniella) taylorae* sp. nov., * *Eatoniella (Eatoniella) victoriae* sp. nov.

Fig. 14. Distribution of *Eatoniella* and *Crassitoniella* species. ● *Crassitoniella erratica erratica* (May), ★ *Crassitoniella erratica subbicolor* (Ludbrook), △ *Crassitoniella flammea* (Frauenfeld), * *Eatoniella (Eatoniella) hewittae* sp. nov., ■ *Eatoniella (Albosabula) pellucida* (Tate & May).

SOME WOODEN ARTEFACTS FROM THE NORTH COAST OF NSW: NEW ARCHAEOLOGICAL AND ETHNOGRAPHIC DATA

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SUMMARY

This paper describes some wooden artefacts recovered from sites on the North Coast of New South Wales, and discusses their radio carbon age and significance. The specimens were recently donated to the Museum's Collection.

INTRODUCTION

This paper records and discusses the cultural context of three dated items from the North Coast of New South Wales. All were recovered by chance from waterlogged deposits during dredging or farming activities not found during systematic archaeological investigations. They include one boomerang from the Clarence River at Grafton, and a boomerang and one point from a multi-pronged fishing spear found in swamp deposits at Collombatti on the Lower Macleay north of Kempsey.

Aboriginal technologies as recorded in the immediate contact period depended to a considerable extent on organic raw materials. Many major items in the 'extractive tool kit' of hunting weapons as well as basic tools and utensils were made of wood and bark fibres, and so are unlikely to survive in archaeological deposits, even of relatively recent age. Unfortunately, the material culture of east coast Aborigines was not fully described at the period of European settlement, while it is only recently that anthropologists and prehistorians have revived interest in Aboriginal technology. Their attempts to reconstruct the material culture have been based on the evidence of ethnohistorical sources and museum collections, often themselves neither comprehensive nor even adequately documented. A great opportunity to record the material adaptation to the rich environments of the temperate and the sub-tropical east coast regions was lost in the late nineteeth century; we are now forced to attempt piecemeal reconstruction from fragmentary literary and artefactual evidence.

Many of our museum collections represent items made decades after settlement, when traditional methods of artefact prepartion and the use of traditional materials were being modified by culture contact. Pre-settlement artefacts, or those collected early in the contact period, are therefore of considerable interest for studies of material culture. Dated wooden artefacts from geological or archaeological contexts, of course, have particular significance, especially as they give further evidence on the antiquity of certain items in the total assemblage, and on the tool kit as a whole.

1. BOOMERANG FROM THE CLARENCE RIVER (E66715)

DISCOVERY: This artefact was recovered by Grafton geologist Reginald Oxenford during dredging operations in the Clarence River between Seelands and Grafton, at a location half a mile downstream of the Southampton Ferry. It lay below twelve feet of

Records of the Australian Museum, 1977, **Vol. 31 No. 16,** 660-671 Figures 1-5.

gravel and shingle in the river bed, seventy five yards out from the eastern bank. Such a context immediately aroused exciting speculation on the possible age of the find. However, studies of the geological setting by Dr. Gutsche of the Geology Department at the University of New England suggest that this need not imply any great antiquity. There are uncertainties involved in assessing rates of sedimentation in a stream bed such as that of the Clarence, while frequent flooding and alteration of the river course creates movement and re-deposition of material from, and within the stream bed. The boomerang's depth in the gravel beds need not, therefore indicate considerable age. In fact re-deposition and later incorporation in the gravel beds is implied by the differential preservation of the two ends of the artefact (See Fig. 1). One is badly warped and broken, suggesting that the boomerang lay for some time in shallow mud with this end exposed above the surface, while the other was covered and protected, before becoming incorporated totally in deeper waterlogged deposits.

DESCRIPTION: The boomerang is a plain, undecorated type, with no twist in the body, and a lenticular cross section. It has a very shallow curve, and the one undamaged end has been shaped to a slight point (Figs 1 and 2). This form, and the lack of decoration, is consistent with other known boomerangs from the Clarence Valley. No tooling marks could be discerned, but in view of the condition of the wood this need not indicate that they were originally absent. The wood had been subjected to fungal attack and there was also some degradation (H.D. Ingle pers. comm.). The boomerang was made of wood from a tree of the genus *Planchonella*, one of the Sapotaceae (probably *P. australis* — H.D. Ingle pers. comm.). This is a rain forest species producing dense, fine textured wood that is close grained and tough, so very suitable for making a throwing artefact.

DIMENSIONS: Assuming the arms of the boomerang to have been equal, length across the chord would have been 47 cm. The width at the centre is 5.6 cm.

DATE: Early in 1967 a wood sample taken from the broken end of the specimen was submitted to Professor Kigoshi of Gakushuin University, Tokyo for dating. The radio-carbon date for this sample (GaK 1299) was 140 $\pm$ 70 B.P. a modern result which Professor Kigoshi considered could represent a true age of some 300 years or more; it is best interpreted as indicating an age of less than four hundred years. So we can consider this boomerang as belonging to the period of the immediate pre-contact centuries, as it is unlikely to have been made from old, dead wood.

COMPARISON WITH ETHNOGRAPHIC DATA: This artefact, in form and size (See Figs. 1 and 2) closely parallels other Clarence Valley examples in the collections of the Australian Museum (for example E8113 from Copmanhurst). However, it seems to be smaller in length (though not in width) than examples from the Richmond River district to the north. Of twelve specimens from this area which I have recorded the mean length is 57.4 cm; mean width 5.6 cm. The difference in length may be due to underestimation of this measurement (which was based on judging the original curve), or to some distortion of the wood itself. The smallest of the Richmond River collection studied had a length across the chord of 54.9 cm. Interestingly *Planchonella* is not recorded in the local historical sources as used by the Aborigines to make wooden artefacts. However, it would have been available in the rain forest stands of the lower Clarence, so this need not imply that the item is of non-local manufacture. Maiden and the local historical sources all state that in this region the wood of the tulip tree *(Lagunaria patersoni)* was used for boomerangs (J. H. Maiden 1898: 380-381, 560; Cf. McFarlane, 1935). Dawson mentions use of mangrove wood as well *(Avicenna officenalis)*, (R. L. Dawson 1935: 13 and 22). McFarlane gives the following description of boomerang manufacture on the Clarence:—

> It is hewn from the spur of a tree, generally one of the tulip species, retaining the natural curve of the root buttress, and, as the timber of the tree named is

open-grained, is easily polished and worked by the simple tools the abo possesses in his laboratory. It is about four inches in width at the curve centre, tapering to two and a half inches at the ends which are slightly twisted, propeller fashion, to cause the weapon to perform a devious course on its aerial passage from the hand of the thrower.

The boomerang is only about a third of an inch in thickness at its stoutest part, and, like the spear, is hardened and blackened by the application of fire (McFarlane 1935).

2. WOODEN ARTEFACTS FROM TRIAL BAY CREEK, COLLOMBATTI (E67211, E67212).

DISCOVERY: Mr. J. B. McIver of Warrell Creek uncovered the boomerang and spear point about thirty years ago when excavating a trench to retain water in the bed of Trial Bay Creek, then dry during a period of severe drought. This creek bears various names as it finds its way from the ranges near Taylors Arm to the old Macleay channel and so into Trial Bay. For most of its length it once crossed extensive swampy tracts to the west of Clybucca, now greatly restricted by drainage undertaken some fifty years ago. The original discoveries made by Mr. McIver included one boomerang in very fragile condition, and one spear point (both described here), together with fragments of a second boomerang and two other spear points. These were apparently found at a depth of eight feet in deposits consisting of four feet of clay underlying about four feet of 'peaty material'. The points when uncovered were clustered in vertical position, suggesting that they were part of the one artefact, presumably a multi-pronged spear. Mr. McIver considered that the shaft of the spear could well also have been in the deposit but dragged away by the scoop of the earth-moving machine before it was recognised as part of a wooden artefact. The two boomerangs were at the same depth but about four to five feet distant. Mr. McIver also noticed some shells in the clay (of the ocean beach species *Plebidonax deltoides);* however, these did not form a consistent layer of shells. The second boomerang was in poor condition when found, and did not survive removal from its waterlogged context, nor did the other two spear points, which Mr. McIver describes as identical to the surviving example.

DESCRIPTION: The boomerang is a plain, undecorated example, as far as may be ascertained from its present condition (see Fig. 3), with a gentle curve and slightly pointed end. Measurements of this example would hardly be useful in view of the fragmentation and distortion of its original form. Its dimensions are best appreciated from the photograph (Fig. 3). However, its maximum width is approximately 5.0 cm, its thickness 0.7 cm. It is lenticular in cross section.

The remaining spear point, in spite of some degradation of the wood, has retained its form relatively well (See Fig. 3). It was originally of fire-hardened wood, the surface now badly eroded. The shaft tapers to both ends, but more sharply to one than the other, which allows one to distinguish the tip end from that which was attached to the shaft of the spear. The difference may be appreciated if one compares the widths at 10 cm from each end; one is 0.9 cm, the other 1.3 cm, equivalent to the maximum width of the point at its centre. The point is 66 cm long, and circular in cross section with a diameter of 1.3 cm at the centre.

DATE: These artefacts are of interest as their location suggested some antiquity. So, in spite of the long elapse of time since their original discovery, and the handling they had received in the interim, it seemed worth while submitting samples for radio carbon dating. However, only the boomerang could be considered for providing a sample since the point could not supply sufficient material for a valid date without destroying its form.

It was in too fragile a condition, and the outer surface of the wood too eroded, to allow coring to obtain wood for dating. As examples of multi-pronged fishing spears from New South Wales are rare, this specimen has additional importance both as an item of material culture and as a museum specimen. As the boomerang lay in the same clay deposit as the point, separated by only four to five feet and at the same depth, it seems a reasonable assumption that they both belong to approximately the same period, and to the same phase of human activity around the creek or swamp. However, this *is* an assumption, and uncertainties of deposition and movement of material within the discrete layers of swampy deposits, especially near stream channels, must be kept in mind when one applies the date for the boomerang to the spear point.

The radio carbon age of the boomerang (assuming that it was made from living wood) lies between 410-550 years (480 ± 70 B.P.), so we may definitely regard it as a pre-contact example (ANU 1628).

COMPARISON WITH ETHNOGRAPHIC DATA: The boomerang, in its present state of preservation shows no features inconsistent with those characteristic of plain, undecorated boomerangs from the North Coast, of which we have extant examples (Cf. Figs 3 and 4). The spear point, however, is of some considerable interest as it appears to have been part of a multi-pronged spear, of three prongs (Cf. Figs 4 and 5). The multi-pronged fishing spear is a piece of coastal New South Wales equipment well known from the ethnographic and historical sources. It is recorded for areas from the South Coast, the Sydney district, and as far north as the Hastings, Macleay and Bellinger Rivers. Curiously it is not reported from the coast further north, from the Clarence or Richmond districts. This present discovery lies within the area of known distribution on the evidence of the ethnographic literature. Though well known from the literature, this particular spear type is very poorly represented in museum collection from New South Wales, especially those of Australian museums. There are the three examples from Botany Bay collected by Cook and Banks in April 1770, housed in the Cambridge University Museum of Archaeology and Ethnology (Megaw 1969, McBryde 1970), and two examples in the collections of the British Museum (one a very early item from Port Jackson). I know of only one other example, at Geneva. McCarthy has described one specimen in a private collection, a spear with three bone-barbed prongs from Wallaga Lake, and a series of prongs recovered from a cave near Lake Wonboyn (McCarthy 1940:315-6, Plate XXXIII). Even a fragmentary part of one of these spears acquires considerable value as material documentation of an important item of Aboriginal fishing gear, a value which is enhanced if the age of the specimen may be determined.

The description of the spear in the ethnographic literature suggests a consistent range of features: the spear shaft consisted of two elements, joined by gum and cords of bark fibre, to which were attached the prongs (three or four in number) themselves usually barbed with small bone points. The whole spear attained a length of twelve to fifteen feet, but this could be adjusted according to the needs of the occasion by manipulating the two elements in the main shaft. The spear was used by men when fishing, either in the shallows or from canoes (Fig. 5). It was not used by women, who, in the areas in which this spear was used, fished with hook and line. The distributions of these two items of fishing gear seem to coincide for coastal New South Wales; there is no record of line fishing from the Far North Coast where the multi-pronged spear was not used.

Collins gives us a description of this spear for the Sydney district:—

> . . . . The fiz-gig is made of the wattle; has a joint in it fastened by gum; it is from fifteen to twenty feet in length, and armed with four barbed prongs; the barb being a piece of bone secured by gum. To each of these prongs they give a particular name, but I never could discover any sensible reason for the distinction.

(Collins 1804 Appendix IV: 556-557 Cf. Barrington 1802:16; Hunter 1793: 62-63; White 1790: 189; Flanagan 1882:81-82; *Endeavour Journal of Joseph Banks*, April, 28 1770.)

John Henderson, who took up land on the Macleay in the early stages of the valley's settlement, gives supplementary local details:—

> At other times, they spear fish from a canoe, or from the bank, in which case they use commonly a *mutach*, or smaller spear, having four or five points, and discharged from the hand. On the coast I have seen these, barbed with kangaroo teeth, and used in the bays and shallows . . .
>
> (Henderson 1851: II, 37 Cf II, 145; Cf Fig. 5).

The descriptions in the literary evidence may be matched by the known ethnographic specimens, two in the British Museum and three at Cambridge. Of the two examples in the British Museum (944 and 1926 3-13.35) one (944) has a sure provenance as a Port Jackson item, and so must have been collected early in the settlement period. It came to the British Museum from the Arley Castle collection, and is registered as 'Fiz-gig, used by the natives to spear fish'. The spear has four prongs and a two-piece shaft, the joins being effected by bands of bark fibre cord cemented with gum, each join measuring 5.5 cm. The two pieces of the shaft measure 85 and 64 cm and the prongs 75 cm, so the total length of the artefact is 235 cm. The other example in the British Museum is also a four pronged spear, but the prongs are not barbed. The shaft is made up of two elements, measuring 80.5 and 61 cm, joined by a band of bark fibre cord covered with gum 4.5 cm long. The prongs of this spear are 61 cm long, and its total length is 213.3 cm.

In the Cambridge University Museum of Archaeology and Ethnology are three multi-pronged spears and one plain spear (1914: 1-4), part of a collection made by Cook and Banks at Botany Bay in April 1770, which came to the museum in 1914 from Trinity College. The multi-pronged spears in this group consist now of the heads and part of the shaft only, this having been cut either to facilitate storage or because of damage to the shaft. So total measurements are not possible, nor can one ascertain whether these also had two-piece shafts. The three prongs are inserted into the shaft, and secured by a binding of bark fibres and gum; they are barbed with small bone points (See Mulvaney 1975: Plate 36). The measurements are given here for one example (1914:1). It has three prongs 52.5 cm to 54.5 in length and c. 1 cm in diameter, each barbed with a bone tip about two cm long bound to the point with fibre cord and gum. The remaining length of shaft is 136.7 cm with a diameter of 1.7 cm.

The ethnographic literature, and the five surviving specimens of this spear type in British Museums document its role in the material culture of coastal New South Wales in the late eighteenth and early nineteenth centuries. It would be of interest to know the antiquity of this item of fishing gear. Certainly the dated example from the Macleay would extend our knowledge of its chronology by some three centuries.

Archaeological sites located within the area of the distribution of this spear type have yielded assemblages which include a high proportion of small bone points. These assemblages date to the last millennium, succeeding the backed blade dominated assemblages, and are associated with the first evidence for the use of shell fish hooks. If we associate the bone points with fishing spears then the cultural change seems to represent a change in coastal fishing techniques. Evidence from such sites as Bass Point and Durras North would suggest that this change took place on the South Coast six hundred to four hundred years ago (Bowdler 1970; Lampert 1966) while for the Sydney district it can be dated to about 900 years ago. If we take the dated spear point from Collombatti as a fifteenth century example, then this particular item of fishing

equipment, (which seems so characteristic of the material culture of coastal New South Wales south of the Bellinger in its latest period of prehistory) was established at the northern extreme of its distribution area by the same period as it appears in the south.

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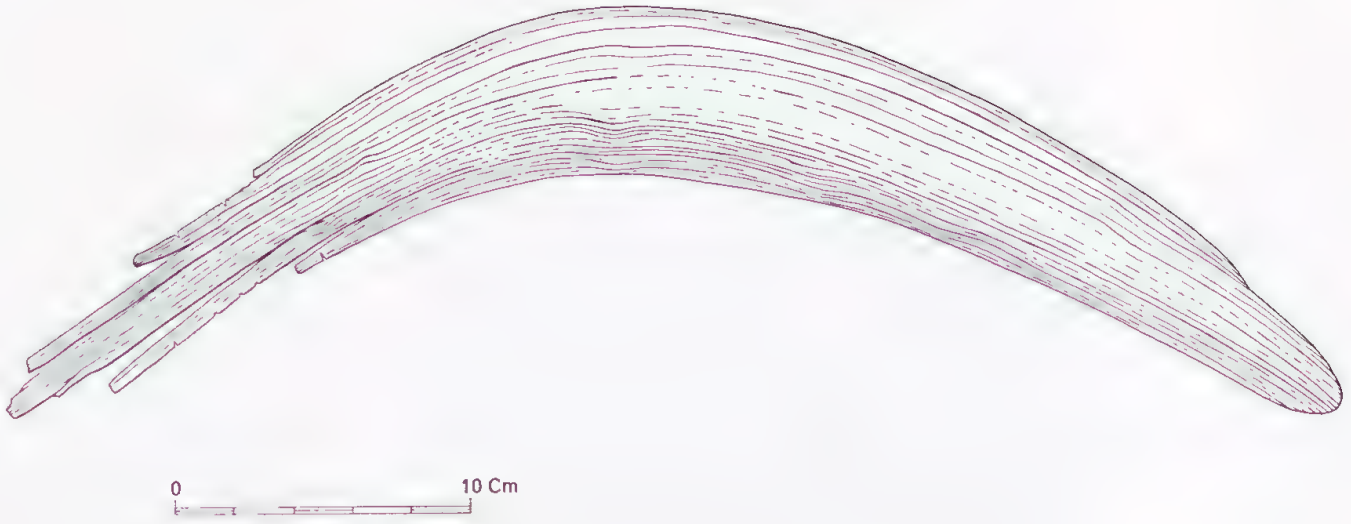

Fig. 1. Boomerang from the Clarence River near Grafton before removal of the damaged end for radio-carbon dating. Australian Museum Reg. No. E66715.

Fig. 2. Boomerang from the Clarence River after removal of the damaged section to provide the dating sample. Australian Museum Reg. No. E66715.

Fig. 3. Boomerang and spear point from Trial Bay Creek, Collombatti, Macleay River district. Australian Museum. Reg. Nos. E67211, E67212.

Fig. 4. Aboriginal man collecting oysters in a tidal creek of the Hastings River estuary photographed by Thomas Dick early this century. Note his boomerang and his two multi-pronged fishing spears. These seem to have one-piece shafts (as distinct from the 'fizgigs' of the Sydney district in the contact period) and three unbarbed points.

Fig. 5. Multi-pronged fishing spears in use in the Hastings River district, another historic photograph of rare interest taken by Thomas Dick.

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EXCAVATION OF A ROCK SHELTER, NEW IRELAND
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Taxonomic Revision of Recent Australian Nuculidae (Mollusca: Bivalvia) Except *Ennucula* Iredale, 1931

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SUMMARY

Taxonomy and distribution of 14 Recent Australian species of the family Nuculidae Gray, 1824 are described and discussed. Available data on biology and ecology are added. Illustrations and distribution maps of all species are given.

The genera *Pronucula* Hedley, 1902, and *Deminucula* Iredale, 1931, are considered synonyms of *Nucula* Lamarck, 1799. *Rumptunucula* is proposed as a new genus for *Pronucula vincentiana* Cotton and Godfrey, 1938. Lectotypes are selected for *Nucula pusilla* Angas, 1877, *Nucula micans* Angas, 1878, *Nucula torresi* Smith, 1885, *Nucula dilecta* Smith, 1891, *Nucula hedleyi* Pritchard and Gatliff, 1904, *Deminucula praetenta* Iredale, 1924, *Pronucula mayi* Iredale, 1930, and *Pronucula saltator* Iredale, 1939. *Nucula micans* Angas, *Nucula hedleyi* Pritchard and Gatliff, and *Pronucula concentrica* Cotton, 1930 are considered synonyms of *Nucula pusilla* Angas. *Pronucula voorwindei* Bergmans, 1969 is synonymized with *Nucula torresi* Smith. *Nucula diaphana* Prashad, 1932 and *Pronucula flindersi* Cotton, 1930 are ranked as subspecies of *Nucula dilecta* Smith. The study also includes *Pronucula decorosa* Hedley, 1902, *Nucula beachportensis* Verco, 1907, and *Pronucula australiensis* Thiele, 1930, while four new species are described: *Nucula revei, Nucula covra, Nucula papuensis* and *Nucula brongersmai*. Notes on the zoogeography of the species involved are given.

INTRODUCTION

When, as a novice in the malacological field, I was first involved in the study of Australian species of the family Nuculidae Gray, 1824 my studies eventually resulted in two small publications (Bergmans, 1968; 1969). The first publication contained an account of six small nuculid species found in New South Wales, the second described a new species in the same category. The identifications in the first paper were mainly based on original descriptions and illustrations in literature, and the nomenclature used was taken from Hedley (1902), Iredale (1924), Cotton (1930) and Cotton and Godfrey (1938), with the assignation of all six species to the genus *Pronucula* Hedley, 1902. Both procedures, induced by the combination of the lack of comparative material and an uncritically high evaluation of earlier works, soon proved to be inadequate. Later opportunities to examine type material of these species and of others, and to study an extensive material of Australian Nuculidae in museum collections, revealed firstly that I had made — and published — several misidentifications, which needed correction, and moreover, that the taxonomy of the Australian Nuculidae required a general revision. My original intention to restrict my work to small New South Wales Nuculidae had been expanded already by the necessary study of type and other material from other Australian states.

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The second limit I imposed was that of the genus *Pronucula*. An effort to clearly delimit this genus from other nuculid genera failed and posed the question of whether it could be maintained as a valid genus. As will appear in the following pages, it could not. An acceptable compromise was finally made by including all Australian Nuculidae with the exception of those species originally or subsequently assigned to the genus *Ennucula* Iredale, 1931. The selection thus made comprises all small species, i.e. with greatest valve length not exceeding 8 mm, with the exclusion of *Ennucula orekta* Iredale, 1939, and *Ennucula privigna* Iredale, 1939. A further restriction is the time scale considered. Although occasionally reference is made to fossils only Recent species are considered in detail. It must however be emphasized that in taxonomic or zoogeographical studies of recent material of geologically ancient and apparently slowly evolving taxa like the Nuculidae (Quenstedt, 1930; Dickins, 1963) it is of the utmost importance to be aware of the fossil evidence from the area concerned (compare Hedley, 1902: 287).

The following abbreviations of collections are used:
AM — Australian Museum, Sydney
BMNH — British Museum (Natural History), London
NMV — National Museum of Victoria, Melbourne
RMNH — Rijksmuseum van Natuurlijke Historie, Leiden
SAM — South Australian Museum, Adelaide
TAS — Tasmanian Museum, Hobart
WAM — Western Australian Museum, Perth
ZMA — Zoölogisch Museum, Amsterdam
ZMB — Zoologisches Museum, Berlin
ZSI — Zoological Survey of India, Calcutta

METHODS

Beside *Pronucula* Hedley two other genera fall within the scope of this paper: *Protonucula* Cotton, 1930, and *Deminucula* Iredale, 1931. Both are monotypic and, as with *Pronucula*, type material of their type species has been examined. To evaluate these genera correctly, the superspecific taxonomy of the Nuculidae, in so far as genera occurring in Australian waters are concerned, is discussed in the first pages of the taxonomic section. This is followed by the descriptions of the species considered, which have been standardized generally in accordance with the directives given by Mayr (1969), and by a key to adult specimens of these species. The descriptions are primarily based on type material, though details of slight and, in my opinion, taxonomically insignificant conchological variation is included. Whenever this variation reaches a degree of possible importance, it is dealt with in the species discussions.

Months in collecting dates are indicated with Roman numerals. Depths are given in metres (m), except in the bibliographic references if originally given in fathoms (1 fathom = 1.8285 m). Measurements are all given in millimeters (mm). In the listing of material examined single valves are listed as ½ (half) specimens. In the measurements *length* stands for greatest valve length, *height* for the height perpendicular to this length, *section* for the section (greatest depth) of a single valve, *embryonic shell length* (abbreviated e. s. l.) for the greatest length of the embryonic shell, and *interdissoconch length* (abbreviated i. d. l.) for the greatest length of the interdissoconch. Both embryonic shell and interdissoconch are best distinguishable in young specimens. The term interdissoconch (initial stage of the post-embryonic shell or dissoconch) is applied to the growth stage following the embryonic stage. This interdissoconch is characterised

by its sculpture (often lacking) and its often distinct margin. In describing shell morphology the term dissoconch has been used for the shell part beyond the embryonic shell plus the interdissoconch, although it could be argued that it does include the interdissoconch. (See also the discussion of *Nucula pusilla* Angas, in the taxonomic section.) The term *primary teeth* (*primary* in the sense of "earliest") is introduced for what possibly are provincular teeth: small vertical teeth or crenulations at either side of the chondrophore, which in some species persist in the adult shell. As opposed to these, the real hinge teeth are called *secondary teeth* (*secondary* in the sense of "coming in time after"). The geographic ranges are based on specimens identified by the author. The illustrations of specimens have been made with drawing attachment, by the author.

TAXONOMY

In 1799 Lamarck described the genus *Nucula*. The type of this genus is the European *Nucula nucleus* (Linnaeus, 1758), neotypes of which were designated, described and illustrated by Schenck (1935). In 1858 Adams and Adams proposed to separate from *Nucula* s. s., into a new subgenus *Acila,* those species with divaricate shell sculpture. The important monograph on *Acila* by Schenck (1936), who raised it to generic rank, provides excellent illustrations of the type species, *Acila divaricata* (Hinds, 1843). Apart from a doubtful taxon, the fossil *Deshayesii* Berge, 1855 (see Vokes, 1967) and the genus *Ptychostolis* Tullberg, 1881 from the Jurassic of the USSR (see Keen, 1969), neither of which needs to be considered here, the superspecific taxonomy of the Nuculidae remained uncomplicated until about the beginning of this century. It is true that before this time several workers have tried to establish two or more "groups" or "divisions" within *Nucula* (see Quenstedt, 1930, and the elaborate historical review by Schenck, 1934), but such categories were never formally proposed as systematic units.

In 1902 Hedley described a new nuculid species from off Port Kembla, New South Wales, which he made the type of the new genus *Pronucula*. It deserved distinction, in his opinion, because "this genus differs from *Nucula* by having the hinge line arched instead of angulated, the rows of teeth do not meet or overlap between the umbones, but are distant from the chondrophore, which is not oblique as in *Nucula,* but perpendicular. Briefly, the constituents of the hinge, which in *Nucula* are much compressed and perhaps slightly rotated, are here wide spread. The shell has not the trigonal contour of *Nucula,* is far thinner and the radial sculpture more pronounced than in that genus. Neither lunule nor escutcheon are present." The type species was named *Pronucula decorosa,* and as second species Hedley included in his new genus *Nucula minuta* Tenison Woods, 1877 the types of which he had examined. This inclusion must have confused a number of later authors with regard to the definition of *Pronucula,* which was obviously based on *Pronucula decorosa*. The apt criticism by Pritchard and Gatliff, as early as 1904, in which they stated that their shells of *Nucula minuta* Tenison Woods were "apparently indistinguishable from *Nucula*", unfortunately escaped the attention of later students. The matter has scarcely been discussed since and the concept of the genus *Pronucula* was widened further by the assignment to it of a variety of nuculid species of which the main decisive character not infrequently must have been their small size.

In 1915 Oliver described *Pronucula kermadecensis* from the Kermadec Islands, and figured it correctly (I studied some paratypes held in the Australian Museum collection) with a slightly angulate dorsal margin and a distinctly oblique chondrophore which is overlapped by the anterior teeth row. *Pronucula mesembrina* Hedley, 1916, from Macquarie Island, has, according to the original drawing, a chondrophore more oblique than perpendicular and there are no edentulous spaces between the teeth rows and the

chondrophore. In 1924 Iredale referred *Nucula pusilla* Angas, a species with an oblique chondrophore overlapped by anterior teeth, to *Pronucula*. *Pronucula tenuis* Powell, 1927, from South-West Otago, New Zealand, has a hinge with "a narrow central part," that is dorsal to the chondrophore, "with 6 minute, indistinct tubercles" (see the discussion of *Nucula covra*, n. sp., in this paper). In 1930 Thiele described *Pronucula australiensis*, from Cockburn Sound, southern Western Australia, a species with concentric sculpture only, and with a smooth inner margin. In 1930 Iredale added *Pronucula mayi* to the genus in so naming the shells taken off Pilot Station, south-east Tasmania that had been identified as *P. decorosa* Hedley by May (1915), a species possessing a much more compressed hinge and a much finer radial sculpture (Figs. 33-35). *Pronucula concentrica* Cotton, 1930, has an oblique chondrophore which is overlapped by the anterior teeth row (see Fig. 13 in this paper), and *Pronucula flindersi* Cotton, 1930, has no sculpture at all, and a smooth inner margin (see its redescription in this paper, and also Fig. 62). Without comment Cotton (1930) placed *Nucula micans* Angas in *Pronucula*, a rather smooth form with an oblique chondrophore (Figs. 6, 7). Marwick, 1931 described *Pronucula totangiensis* from Tertiary layers in the Gisborne District, New Zealand, a species with a distinctly angular dorsal margin, to judge from its original figure. *Pronucula maoria* Powell, 1937, from off Three Kings Islands, New Zealand, has what to me seem teeth rows that meet over the chondrophore, which itself can hardly be called perpendicular. Cotton and Godfrey, in 1938, published *Pronucula vincentiana* from Gulf St. Vincent, South Australia, failing to notice that its hinge configuration, instead of approaching that of *Pronucula*, is strikingly different from all known Nuculidae (see its redescription in this paper). In 1939 Iredale placed in this genus his new species *P. saltator* from Low Isle, Queensland, an almost smooth species without radial sculpture and with an oblique chondrophore. In 1947 Cotton remarked that the Miocene *Nucula morundiana* Tate, 1886, from the River Murray Cliffs, South Australia, possibly is a *Pronucula* species. Ludbrook (1955) lists it as such. In 1961 he also assigned to the genus *Pronucula* the species *Nucula tatei* Finlay, 1924, from the Upper Eocene of Blanche Point, South Australia, and *Nucula fenestralis* Tate, 1886, from the Oligocene of Table Cape, Tasmania. From the descriptions and figures in Ludbrook (1955, 1961) it appears that *Nucula morundiana* Tate has no real radial sculpture and is much more trigonal than typical *Nucula;* that *Nucula tatei* Finlay also lacks the pronounced radial sculpture of *Pronucula* and has an oblique chondrophore; and that *Nucula fenestralis* Tate has a "slightly oblique" chondrophore. In 1961 Clarke describes *Pronucula benguelana* from the South Atlantic Ocean, about 400 miles north-west of Cape Town in South Africa (depth 3100 m), with the chondrophore "close to the innermost taxodont teeth" and with "narrow" radial ribs. In 1968 Bergmans, following Hedley (1902), Iredale (1924), Cotton (1930) and Cotton and Godfrey (1938), lists six small nuculid species from New South Wales under *Pronucula,* stating that his material is too limited for studies of their relationships, and treating the species "in an order according to their more or less pronuculid hinge".

In 1969 Bergmans describes *Pronucula voorwindei,* dredged off Port Stephens, New South Wales, with a weak radial sculpture and an oblique chondrophore. (This species is presently synonymized with *Nucula torresi* Smith, 1885.)

I have examined the types of *Nucula minuta* Tenison Woods and found that they actually are rather young valves and belong, in my opinion, to *Nucula pusilla* Angas; see also the discussion of this species. Their somewhat quadrately ovate outline and the relatively spacious setting of their hinge teeth are mainly due to their age (see figs 9-11). Their chondrophores are distinctly oblique, and their anterior teeth rows do continue over the chondrophore, while exteriorly they do not show any pronounced radial or other sculpture. For these reasons I do agree with Pritchard & Gatliff (1904) that *Nucula minuta* Tenison Woods belongs in *Nucula* Lamarck.

From the foregoing necessarily concise account of species allocated to *Pronucula* by original or subsequent designation it is clear that none coincides with Hedley's description of this genus in all respects. All these species may possess one or more characters by which they should be judged as relatives of *Pronucula decorosa,* but there are, in every species, also characters by which they more closely fit into the genus *Nucula.* One could, for instance, describe the hinge of *Pronucula mayi* as pronuculid — although it is distinctly more compressed than in *P. decorosa.* However, its outline and its sculpture of delicate concentric riblets, crossed in the median part by equally weak radial riblets, do not indicate this relationship. Still, of the described species, *mayi* seems one of the closest relatives of *decorosa.*

In *Pronucula decorosa* itself it is not the hinge line, but the dorsal margin, that is arched. The two teeth rows enclose a distinct angle, and the difference with *Nucula* is only one of degree. The teeth rows in *Nucula,* writes Hedley, meet or overlap beneath the umbones. Indeed, Schenck (1935) figures the type of *Nucula nucleus* (L.) with an anterior teeth row that runs over the chondrophore and meets the posterior teeth row. A closely related species, *Nucula turgida* Leckenby & Marshall, 1875, well figured in Tebble (1966: 12), also has the anterior teeth row continuing over the chondrophore, but it does not meet the posterior row because this stops at some slight distance behind the chondrophore. A comparable situation is found in adult specimens of *Nucula pusilla* Angas (figs 3, 7 and 13). Edentulous spaces between teeth rows and chondrophore as in *Pronucula decorosa* are found, but to a lesser degree, in *P. mayi* and in *P. australiensis* (figs 34 and 55). Compared with the figures in a former article (Bergmans, 1968) the illustrations in this paper more clearly present a range of chondrophore form and orientation which demonstrates that the implicit direction is always toward the anterior or anteroventral shell side. This is even true for *Pronucula decorosa,* though admittedly exhibited only very weakly. Whenever a nuculid species has a somewhat longer chondrophore, this anteriorly-directed vector in its orientation becomes manifest. The teeth in *decorosa* are not different from those in *Nucula,* being V-shaped and with the tips curved slightly upwards (see for instance fig. 34). The outline of *decorosa* differs from that in typical *Nucula* but any intermediate outline exists in the Nuculidae. The same applies to the relatively moderate thickness of its shell. The radial ribs in *decorosa* are not so much "pronounced" (Hedley, 1902) as well broad, with broad interstices, but again differ from those in *Nucula* species only in a relative sense. (The neotype of *Nucula nucleus,* length 9.3 mm, has according to Schenck's figures (1935) about 5 to 6 radials per mm; the paratype of *Pronucula decorosa* here figured (fig. 39), length 2.45 mm, about 12 to 14 per mm.) Finally, Hedley states that *Pronucula* has neither lunule nor escutcheon. In typical *Nucula* the lunule, if present, is not well defined. The escutcheon however, is, and its absence in *Pronucula decorosa* connects this species with all other species here treated, and cannot be regarded as of taxonomic significance. Especially in a number of these species that are radially sculptured over the median part of the valve only, the anterior and posterior shell areas could easily be taken for lunule and escutcheon, respectively, though these areas are never really depressed.

As I hope to have demonstrated no species that has been regarded as belonging to the genus *Pronucula,* possesses a set of characters which would warrant its separation from *Nucula.* I therefore propose to sink *Pronucula* Hedley, 1902, into the synonymy of *Nucula* Lamarck, 1799, and to assign to that genus all the Australian species treated here except *Pronucula vincentiana* Cotton & Godfrey, for which a new genus is proposed. This synonymy follows that of Thiele (1934), who however did not present any arguments. Schenck (1934) lists *Pronucula* as a genus, but it appears that because of lack of specimens to examine he could do nothing else. Van de Poel (1955) recognizes only three genera in the Nuculidae, namely *Nucula* Lamarck, *Nuculoma* Cossmann, 1907, and *Acila* Adams &

Adams. He ranks *Pronucula*, because of its denticulated margin, as a subgenus of *Nucula*. He does not go into its differences from other taxa. Keen (1969) lists *Pronucula* as a genus, with *Austronucula* Powell, 1939, as a subgenus, though the reasons for this decision are not given.

In 1931 Iredale described the genus *Ennucula* to accommodate Australian species which, in his opinion, differed from typical *Nucula* in having "a notably oblique chondrophore, above which the teeth become much smaller", while the "angle of opposition of the two rows of teeth is scarcely marked", and the edge of the shell is "practically smooth". He proposed *Nucula obliqua* Lamarck, 1819, as type of this genus. A glance at a specimen of *Nucula nucleus* (or the illustrations in Schenck, 1934) is sufficient to decide that the differences between these genera are a matter of degree as far as chondrophore orientation and teeth arrangement are concerned. The angle of opposition of the two teeth rows in *Nucula obliqua* Lamarck (type figured in Schenck, 1934) is not much greater than in *N. nucleus* (L.) and the difference is certainly not of taxonomic importance. The remaining distinguishing character, a smooth inner valve margin, has been considered of crucial importance by all more recent authors on the classification of the Nuculidae: Quenstedt (1930), Thiele (1934), Schenck (1934) and Van de Poel (1955). It has been demonstrated more than once that a denticulated margin is directly related to a radial prismatic inner shell structure (Schmidt, 1922; Bøggild, 1930: Quenstedt, 1930; Wrigley, 1946; Taylor, Kennedy & Hall, 1969), which, according to some authors, smooth-margined species would not possess (Quenstedt, 1930; Van de Poel, 1955). However, Taylor, Kennedy & Hall (1969) claim such a structure also for the smooth-margined species involved in their shell structure studies, *Nucula laevigata* (Sowerby, 1818), *Acila castrensis* (Hinds, 1843) (cited as *Nucula*), and *Acila cobboldiae* (Sowerby, 1818) (erroneously cited as *Acila cobboldiana*).

As long as an examination of the shell structures of the individual, smooth-margined species *Nucula australiensis* (Thiele, 1930), *Nucula papuensis* n. sp., *Nucula brongersmai* n. sp., and *Nucula dilecta* Smith, 1891, treated in this paper, has not been carried out I prefer to assign them to *Nucula*. In the former three species this placement is supported by observed radial strieae, and in the latter by faint traces of a radial lining in the shells of some specimens.

An extensive discussion of the validity of the genus *Ennucula* can thus be omitted here, but it seems useful to remember that it has been synonymized with *Leionucula* Quenstedt, 1930, by Thiele (1934), who was followed in this — in spite of Iredale's defensive remarks (1939) — by Eames (1951), Macpherson & Gabriel (1962) and Keen (1969), while Van de Poel (1955) preliminary lists it as a subgenus of the first smooth-margined genus described, *Nuculoma* Cossmann, 1907 (described in: Thiéry & Cossmann, 1907).

In 1931 Iredale also proposed the new genus *Deminucula* for *Nucula praetenta* Iredale, 1924. In 1924 he wrote of this species that it was "a true *Nucula*", but in 1931 it is explained that he meant *Nucula* "in the broad sense". Since he had, in the same article, denied the existence of typical *Nucula* species in Australia, and referred Australian species that had been so classed to his new genus *Ennucula*, *Deminucula* is only compared with this genus, and not with *Nucula*, with which it nevertheless happens to share most of it's generic characters. *Deminucula* has "the surface radially rayed, the inner margin of the shell denticulate and the hinge line more angular than it is in *Ennucula*, the teeth more distant, the chondrophore small and scarcely exceeded by any teeth". With regard to *Pronucula* Iredale confines himself to the remark "I have noted that *Nucula praetenta* was not a *Pronucula* . . . ". In 1939 he describes an obviously

related species as *Pronucula saltator*. The characters that would distinguish *Deminucula* from *Nucula* Lamarck, are already sufficiently dealt with in my arguments for the synonymy of *Pronucula* Hedley with *Nucula*. Suffice it to state that I regard *Deminucula* Iredale, 1931, as a synonym of *Nucula* Lamarck, 1799. (In my discussion of *Deminucula praetenta* it will be explained that McAlester's opinion (1969), according to which *Deminucula* would belong in the family Malletiidae Adams & Adams, 1858, is based on incorrect illustrations in Schenck (1934).)

Finally, some remarks should be made on *Protonucula* Cotton, 1930, which as appears from the context, was described as a genus in the family Nuculidae. The type and only species, *Protonucula verconis* Cotton, 1930, because of its length of only 3.5 mm would fall within the scope of this paper. Schenck (1934) remarks that this genus would probably more correctly be allocated to *Tindaria* Bellardi, 1875, and thus to a family other than the Nuculidae, namely the Malletiidae Adams & Adams, 1858. Fleming (1948) supports this, saying that *Protonucula* "is apparently an Australian relative of *Tindaria*". I studied SAM samples D 1644, from 130 fathoms off Cape Jaffa, and D 1645, from 300 fathoms off Cape Jaffa (South Australia), both mentioned by Cotton in his description of *Protonucula verconis*, and which are thus to be regarded as paratypes (Mayr, 1969: 371). These shells are certainly not nuculids. Cotton's description and figures are incorrect. The valves are quadrately ovate, almost equilateral, thin, smooth, with no apparent radial structure. The hinge plate is interrupted in the middle, beneath the umbo. In one specimen there are 13 anterior and 11 posterior teeth, the rows being almost equal in length. The rather small teeth are V-shaped — with the leg of the V at the side of the valve margin longer than the other — and not very long or pointed. Beneath the hinge plate interruption there is a triangular thickening of the valve (a resilium?), visible when the inside of the umbo is examined. From old labels it appears that Verco had classified the species as *Nuculana Link*, 1807.

Nucula Lamarck, 1799

Nucula Lamarck, 1799: 87.

Pronucula Hedley, 1902: 290.

Deminucula Iredale, 1931: 202.

Nucula pusilla Angas

Figures 2-14

Nucula pusilla Angas, 1877: 177, pl. 26, fig. 26.

Nucula micans Angas, 1878: 864, pl. 54, fig. 16. New synonymy.

Nucula hedleyi Pritchard & Gatliff, 1904: 237 (new name for *Nucula minuta* Tenison Woods, 1877:156 *non* Owen, 1839; *nec* Fleming, 1813; *nec* Defrance, 1825); Bergmans, 1968: 76, pl. 12, figs 5a-f. New synonym.

Pronucula concentrica Cotton, 1930: 224, fig. 2. New synonymy.

LECTOTYPE: A right valve from shell sand, Port Jackson, New South Wales, collected by J. Brazier (BMNH 1877.5.12.61).

DIAGNOSIS: A moderately sized, ovately shaped *Nucula*, smooth or partly sculptured with concentric ribs, with a distinct radial structure in the median section of

the valve (appearing as radial "lines" or striae) and a correspondingly denticulated inner ventral margin, and with a short but oblique chondrophore. From its nearest relative, *Nucula beachportensis* Verco, it differs in being smaller, with a usually less truncated, relatively longer posterior area and a relatively shorter posterior margin, and a less oblique and more projecting chondrophore in adult specimens. The two species seem to differ also in habitat, *N. pusilla* preferring rather shallow waters while *N. beachportensis* is restricted to deeper waters.

DESCRIPTION: Valve moderately solid, quadrately ovate in outline, not very small. Dorsal margin slightly curved. Posterodorsal and posteroventral angulations only sharp in young specimens and usually more rounded in adult ones. Posterior side somewhat truncated, weakly rounded. Anterodorsal curve gradual, anterior side weakly rounded and with a broad curve extending to the evenly rounded ventral margin. Embryonic shell with a granular appearance on median exterior, and a smooth margin. Interdissoconch smooth but for growth lines. Rest of valve with concentric ribs on anterior and posterior areas, sometimes covering the median area also. Usually a few well developed concentric ribs near ventral margin. Beyond interdissoconch shell distinctly radially structured with narrow, prismatic elements (see Taylor, Kennedy and Hall, 1969). Periostracum greenish, sometimes brownish. Shell white. Hinge line arched, chondrophore short, pointing forwards. In lectotype (length 2.60 mm) 10 anterior and 4 posterior, V-shaped secondary teeth. In younger shells some small primary tooth-like projections may be present beneath the beak (Bergmans, 1968). Adductor muscle scars and pallial line usually indistinct. Inner margin finely denticulated by radial structure.

MEASUREMENTS: See Tables 1 and 2

GEOGRAPHIC RANGE: Along the coasts of southern New South Wales, Victoria, Tasmania, South Australia and southern and western Western Australia (fig. 69).

ECOLOGY AND BIOLOGY: *Nucula pusilla* has been collected alive from near beaches to depths of 36.8 m, and dead from beaches and offshore to a maximum depth of 366 m. It probably lives in rather shallow waters. A shell from South Australia (RMNH 16a), length 2.92 mm, contained at least 26 embryos, with embryonic shell lengths varying from 0.41 to 0.45 mm and heights from 0.34 to 0.37 mm. Another specimen from South Australia (BMNH 197115), with a length of 2.9 mm, contained 22 embryos, one of which measured 0.45 mm in length, 0.40 mm in height and 0.25 mm in section (whole specimen). It is clear that in *Nucula pusilla* brood protection exists. From the embryonic shell measurements taken from samples of full-grown individuals (table 2) it appears that the embryos in the two South Australian specimens were about to begin their independent existence.

Table 1. Measurements of Nucula pusilla.

locality	specimen	length	height	section	e.s.l.	i.d.l.
Port Jackson	Lectotype *Nucula pusilla*	2.60	2.15	0.70		
Blackmans Bay	Lectotype *Nucula hedleyi*	1.94	1.47	0.47		0.97
	Paralectotype *Nucula hedleyi*	1.98	1.59	0.46		0.86
Gulf St. Vincent	Holotype *Pronucula concentrica*	3.75	3.22	1.05	0.29	0.86
Brighton	Lectotype *Nucula micans*	2.45	2.08	0.60		
	Paralectotype *Nucula micans*	2.50	2.02	0.65		
Shark Bay		2.36	2.00	0.65	0.31	0.82

Table 2. Nucula pusilla: embronic shell lengths and interdissoconch lengths.

Locality	e.s.l.			i.d.l.		
	n	m	min-max	n	m	min-max
Port Phillip Bay	38	0.31	0.28-0.35	44	0.89	0.86-0.95
Port MacDonnell	5	0.44	0.41-0.45	6	0.83	0.76-0.86
Guichen Bay	16	0.38	0.28-0.41	17	0.88	0.82-0.93

DISCUSSION: The syntype series of *Nucula pusilla* Angas (BMNH, 1877. 5.12.61) consisted of one complete specimen and one loose valve, the latter with the hinge broken off. Unfortunately, during my studies, the left valve of the complete specimen, which I had chosen as lectotype, and the loose valve were accidentally destroyed. Consequently the remaining and undamaged right valve became lectotype of the species (Figs. 2-4). My studies of those species, which I now consider to be conspecific with *Nucula pusilla* Angas, namely *Nucula micans* Angas, *Nucula hedleyi* Pritchard and Gatliff and *Pronucula concentrica* Cotton, started with the examination of the type material. In the cases of *N. micans* and *N. hedleyi* no holotype specimens had been indicated by their original describers. Moreover, the original illustration of a *N. micans* syntype is very poor, while for *N. hedleyi* no syntype has ever been figured. Before concluding their synonymy with *N. pusilla* I selected lectotypes of both species and made drawings of them. In the case of *P. concentrica* the type specimen had been registrated as such, but again the original illustrations of this species are poor and in some respects even misleading. For these reasons it is figured here too (Figs. 6-12).

Typical *Nucula pusilla* have been collected from New South Wales (as far north as Port Stephens), Victoria, Tasmania, and eastern South Australia (Port MacDonnell and Robe). In larger samples there are almost always some specimens with thinner and smoother shells than in the typical form, and sometimes with an atypical, rather quadrate outline due to a more pronounced anterodorsal angulation. Intermediates between these and the typical form are equally encountered in the same samples, and I regard the observed variation as intraspecific.

In populations from off Lakes Entrance, Victoria, to Geraldton, Western Australia, and also around Tasmania, *pusilla* shells are more heavily built than typical ones, with relatively broader umbones and thicker valves. Moreover these shells sometimes feature bluntly truncated posterior sides and almost linear and quite sharply descending anterodorsal margins, resulting in a rather triangular valve outline. Again, intermediates between these and typical *pusilla* have been found as well, especially where the distribution areas overlap (e.g. Western Port Bay and Corio Bay in Victoria). From about the same regions, from off Lakes Entrance in Victoria to Careening Bay, Garden Island, Western Australia, shells have been collected with distinct concentric ribs covering the whole valve beyond the interdissoconch. This sculpture seems to be a constant character in some populations, but definitely not in all. From between Robe and Lakes Entrance I have seen samples containing both practically smooth and concentrically ribbed specimens. A sample from Port Phillip Bay, Victoria, collected alive (AM C. 100969), consisted of 18 typical and 28 ribbed specimens which otherwise were identical. In my opinion this concentric sculpture can not serve as a sufficient character to separate the ribbed specimens in an apart taxon.

In 1877 Tenison Woods described *Nucula minuta* from Blackmans Bay, Tasmania. Because this name was preoccupied Pritchard and Gatliff (1904) renamed the species as *Nucula hedleyi*. I studied the syntypes, three rather small valves (table 1) and compared them to typical *N. pusilla* of approximately the same size from the New South Wales localities: Collaroy Beach, Watsons Bay and Narrabeen. The series from Narrabeen has been described earlier (Bergmans, 1968). As already argued in my discussion on the validity of the genus *Pronucula* Hedley, I could in no way discriminate the *hedleyi* types from equally sized *pusilla*, and consider the former species as a synonym of the latter. I selected an undamaged left valve as lectotype of *Nucula hedleyi* (figs. 9-11; TAS. E. 18a/7359), which left as paralectotypes a right valve and a heavily damaged left valve (TAS. E. 18b/7359). Turner and Dartnall (1971) erroneously stated that the syntypes would comprise two right valves and one left valve.

In 1878 Angas described *Nucula micans* from Salt Creek and Glenelg, South Australia. He described *N. pusilla*, a year before, as "rather thin", and *N. micans* as "moderately solid", with "a different style of sculpture".
Angas observed "radiating hairlines" in *pusilla*, but failed to describe these for *micans*. In fact these hairlines (the expression of the radial structure) are as clearly visible in *N. micans* as in *N. pusilla*. Other differences in sculpture do not exist either. The syntypes of *micans* are merely representatives of the heavier South Australian *pusilla*, and undoubtedly conspecific, which conclusion reduces *micans* to the synonymy of *pusilla*. A right valve of *micans* was selected as lectotype (BMNH 1879.1.31.8/1) and figured (figs. 6-8), the three other valves becoming paralectotypes (BMNH 1879.1.31.8/2).

In 1930 Cotton described *Pronucula concentrica* from Gulf St. Vincent, South Australia. A study of the type specimen (SAM D.10115) learned that both original description and illustration were inaccurate. The specimen lacks the pointed umbo and rounded posterior side as figured by Cotton, and has an outline like that of *Nucula pusilla*. The concentric ribs do not extend on the interdissoconch and the radial structure visible in *pusilla* is also present in the type of *concentrica*. In fact, I could find no difference between typical *pusilla* and Cotton's *concentrica* other than the concentric sculpture being restricted in the former and not so in the latter. As I have pointed out before, this sculpture is not reliable as a taxonomic character. Smooth and ribbed specimens are found together, and in some cases intermediately sculptured shells have been collected. From Western Port Bay a well-preserved specimen (RMNH 16b), with a smooth median area where traces of concentric ribs are scarcely detectable, was taken together with distinctly ribbed specimens. A difference suggested by the measurements in table 1 is that in the size of adult specimens. The holotype of *Pronucula concentrica* measures 3.75 mm in length, whereas the sexually adult *Nucula pusilla* containing embryos measure only about 2.9 mm. This difference however could not be confirmed as a constant one, which would enable us to separate ribbed from more smooth forms. I therefore consider *Pronucula concentrica* as a synonym of *Nucula pusilla*.

(From beaches at some Western Australian localities — Dongara, Geraldton, Shark Bay, North West Cape, Monte Bello Island — a form has been collected that with some reservation is assigned here to *pusilla*. It differs from typical *pusilla* in being heavier, in featuring a much less distinct crenelation of the ventral margin and a more triangular outline, with the posterior margin slightly excavated by a shallow furrow running from the umbo and weakly defining an area. From other Western Australian *pusilla* it differs in the absence of concentric ribs. The best preserved valve representing this form, WAM 809-71, is from South Passage, Shark Bay; its measurements are given in table 1, and its outline as fig. 5.)

Considering the wide geographical distribution of the forms assigned here to *Nucula pusilla* the studied collections are still quite small. They certainly did not provide a basis for a definite concept of the taxonomy of the species. The classification used in the present study has merely been proposed to accommodate some undoubtedly very closely related forms that could not be separated on shell-morphological grounds. The nature of the observed morphological variation is probably at least partly genetically determined. It is not very likely, after all, that only environmental conditions would account for it. The regions to which certain forms are more or less restricted are far too large to allow the assumption of identical ecological conditions at all the involved localities (with a possible exception for temperature ranges).

The sculpture on the exterior of adult shells of *Nucula pusilla* can be divided into four zones:

1. The microscopically pitted surface of the median part of the embryonic shell.
2. The rather narrow smooth marginal zone of the embryonic shell.
3. The comparatively large interdissoconch, which is smooth but for some fine growth lines.
4. The valve beyond the interdissoconch, with concentric ribs covering anterior and posterior areas and not infrequently also the median area.

Ockelmann (1962), dealing with types of development in mainly northern Atlantic marine bivalves, summarizes what is known about some *Nucula* species from this region. *N. proxima* Say, *N. turgida* Leckenby and Marshall, and *N. nucleus* (L.) reproduce by means of lecitotrophic larvae (larvae reaching metamorphosis solely on nutrient matter from the egg). Free-swimming larvae of the latter two species were observed by Lebour (1938). The pelagic life of these species is very short, lasting from a few hours to a few days at most. According to Ockelmann's observations species with an embryonic shell with two differently sculptured zones of which the outer one is poorly developed, are most likely species with lecitotrophic development and a short pelagic life. This may very well apply to *Nucula pusilla,* although its embryonic shell is comparatively large. Ockelmann (1962) found a length of 0.135 to 0.230 mm, with a rather limited intraspecific variation, for zone 1 (or prodissoconch I, i.e. the inner or oldest embryonic shell zone) in species with this type of development. He did not give measurements for zone 2 (or prodissoconch II, i.e. the outer or youngest embryonic shell zone) but stated it to be absent or poorly developed. My measurements of the lengths of zones 1 and 2 together amount from 0.28 to 0.45 mm, in *N. pusilla.* As Ockelmann observed further, larger measurements of zone 1 and 2 occur in species with brood protection, but he did not mention the magnitude of this increase.

I have considered the smooth and distinctly aberrant stage following the embryonic shell and preceding the final shell stage as an interdissoconch, in *N. pusilla.* It is not certain, however, to what life period this stage corresponds. It seems rather large to be formed during the pelagic stage, assuming this stage would be short as in the northern Atlantic *Nucula* species mentioned above. According to Quenstedt (1930) the development of rib sculpture on the shell exterior in the Nuculidae would be an evolutional adaptation to digging habits, and from this point of view it would not be unlikely that the development of the final shell stage would be initiated by the settling of the specimen in the sandy bottom. The existence in the species of populations wholly or partly without ribbed dissoconchs either speaks strongly against such a direct relation, or points to another possible interpretation of the observed sculptural differences, namely differences in the nature of the substrata.

SPECIMENS EXAMINED: New South Wales: 7/2 from 44 m, off Port Stephens (6/2: AM C.87623; 1/2: RMNH 55084); 1 17/2 from shell sand, Narrabeen, 1961, coll. J. Voorwinde (RMNH 52694); 1/2 conform *Nucula pusilla,* from 146 m, 22 miles east of Narrabeen, 7-VI-1906, coll. H.M.C.S. "Miner," don. W. A. Haswell (AM C.26047); 2/2 from 10.6 m, from rocks below R.S.L. Club, Harbord, 14-VIII-1971, coll. P. Hutchings (AM C.88712); 1 10/2 from Collaroy Beach (AM C.83117); 16 from North Harbour (AM C.83108); 4 4/2 from 11 to 14.5 m, Chinamans Beach, Middle Harbour (AM C.83113 and RMNH 55096); 1/2 from Balmoral (AM C.87624); 1 1/2 from shell sand, Port Jackson (syntypes of *Nucula pusilla* Angas, BMNH 1877.5.12.61); 2/2 from 9 m, off Bottle and Glass Rocks, 1878, coll. J. Brazier (AM C.88711); 5 2/2 from Bottle-glass, Port Jackson (RMNH 55085); 4 from 14.6 m, off Old Man Hat Point, Inner North Head, Port Jackson, 1886, coll. J. Brazier (AM C.88710); 10 19/2, Watson's Bay (Collection Van der Slik); 1 4/2 from Quarantaine Bay, Port Jackson (RMNH 55086); 1 from 14.5 to 18.8 m, George River, Dolls Point, 1961-1962, coll. J. Voorwinde (RMNH 52695); 2 from Twofold Bay (AM C.83109). Victoria: 7/2 from 366 m, 30 miles south of Cape Everard, 22-X-1964, coll. "Endeavour" (AM C. 83128); 1/2 and 12 fragments from 152 m, off Lakes Entrance, 38°13' S, 149°06' E, 20-VI-1962, coll. C.S.I.R.O. Fisheries, H.M.A.S. "Gascoyne" (RMNH 55087); 1 10/2 from Western Port (AM C.28381, NMV F28111, SAM D.15062); 7 from Western Port Bay (RMNH 16b, ZMB 59760); 7 9/2 from 3.6 to 5.5 m, between Eagle and Crawfish Rock, Northwest Arm Western Port Bay, 15-II-1969, coll. W. F. Ponder and B. J. Smith (AM C.88105); 2/2 from Portsea (NMV F19170);46 from Port Phillip Bay, coll. Fisheries and Wildlife Department (AM C.100969); a series from Corio Bay (NMV F28112, RMNH 55088); 1/2 from Cowes (NMV F28121); 2 from San Remo (NMV F28115); 1 2/2 and a series from Victoria (NMV F28123 and F28118). Tasmania: 2 from Bass Strait, coll. J. H. Ponsonby (BMNH 93.3.210.11); 2/2 from Cape Portland, 15-V-1970, coll. G. Davis (TAS E7706); 1/2 from Spring Beach, 2-II-1970, coll. E. Turner (TAS E7533); 1/2 from shell sand, North Oyster Bay, Maria Island, IX-1967, coll. J. Thwaites (TAS E5670); 1 1/2 from Dunalley, 30-VI-1965, coll. L. Crofts and N. Pattison (TAS E4239); 6/2 from corraline algae on intertidal rocks, Pirate Bay, Eaglehawk Neck, III-1970, coll. W. F. Ponder (AM C.83124 and C.88704); 2/2 from White Beach, X-1967, coll. A. Dartnall (TAS E6247); 2/2 from 2 miles south of Tasman Head, Bruny Island (AM C.8323); 1/2 from Derwent Estuary, 11-XII-1916, coll. W. L. May (TAS E19/7360); a series from Derwent Estuary and a series from Derwent Estuary and Gordon Channel, both from the W. L. May Collection (SAM D.15085 and D.15084); 3/2 from Blackmans Bay (syntypes of *Nucula minuta* Tenison Woods, lectotype TAS E18a/7359, paralectotypes TAS E18b/7359); 3/2 from Blackmans Bay (NMV F811); 1/2 from Browns River (AM C.10892); 11/2 from Port Davey, Bond Bay, II-1968, coll. King family (TAS E6191); 1/2 from near Granville Harbour, 23-XI-1967, coll. A. Dartnall (TAS E6305); 20 1/2 from Tasmania (BMNH 197114, RMNH 52693, SAM D.15043, SAM D.15074, TAS E3705, ZMB 59761). South Australia: 6/2 from MacDonnell Bay, coll. J. Verco (SAM D.15061); a series from Port MacDonnell, coll. J. Verco (SAM D.15059); 11 4/2 from Port MacDonnell Beach, coll. J. Verco (SAM D.15060); 22/2 from 73, 201, 274 and 366 m, respectively, off Beachport (SAM D.15068, D.15069, D.15070 and D.15071); a series from Robe (AM C.83112, RMNH 55089, SAM D.15057); a series from Guichen Bay (SAM D.15052); 2/2 from 135 and 238 m, respectively, off Cape Jaffa (SAM D.15066 and D.15067); 2 7/2 from Kingston (SAM D.15053); 5/2 from Encounter Bay (RMNH 55090); 5/2 from Salt Creek, Edithburg, coll. J. Verco (SAM D.15064); 4/2 from Brighton (syntypes *Nucula micans* Angas, lectotype BMNH 1879.1.31. 8/1, paralectotypes BMNH 1879.1.31.8/2); 2/2 from Holdfast Bay (NMV F28110); 10/2 from Henley Beach, 1944, coll. S. Merton (SAM D.15082); 1 from 36.8 m, Gulf St. Vincent (holotype of *Pronucula concentrica* Cotton, SAM D.10115); a series from Gulf St. Vincent (SAM D.15042 and D.15046); 4 from a depth to 36.5 m, Gulf St. Vincent, coll. J. Verco (SAM D.15045); 3/2 from 110.5 m, off Cape Borda (SAM D.15065); 5 9/2 from Hardwicke Bay (AM C.13450 and C.66732); 1 4/2 from Wallaroo (SAM D.15083); 5 2/2 from

Port Elliston (SAM D.15074); a series from Venus Bay (SAM D.15078); 4 1/2 from Carawa, Streaky Bay (SAM D. 15063); 13/2 from St. Francis Island (SAM D.15050); 6 11/2 from St. Francis Island Beach (SAM D.15048); 3 8/2 from 11, 27.5 to 36.5, and 64 m respectively (SAM D.15049, D.15051 and 15058); a series from South Australia (BMNH 197115, RMNH 16a, SAM D.15044, D.15054, D.15055, D.15056 and D.15081). Western Australia: 2/2 from Hopetoun Beach (SAM D.15076); 6/2 from King George Sound Beach (SAM D.15072); 2/2 from King George Sound (SAM D.15073); 1 from 24.5 m, off Bunbury (SAM D.15077); 15 2/2 sieved from mud, 15 m, Skippy Rock, Careening Bay, Garden Island, 16-I-1965, coll. S. Slack-Smith (RMNH 55091, WAM N.4973); 2/2 from Dongara, 11-VIII-1943, coll. G. P. Whitley (AM C.83104); 1 2/2 from Geraldton, coll. Dr. Tott (SAM D.15075); 3 3/2 from South Passage, Shark Bay, mainlandshore, sieved from intertidal sand, 6-III-1966, coll. Wilson and Kendrick (3 1/2: WAM 809-71; 2/2 RMNH 55092); 6 2/2 from Yardie Beach, North West Cape, in tide wash — at low tide, 9-X-1969, coll. F. Plant (WAM 808-71); 1 7/2 from Monte Bello Islands, 18-IX-1945, coll. G. P. Whitley (AM C.100952). Localities unknown: 5 series (SAM D. 15039, D.15040, D.15041, D.15079 and D.15080).

Nucula beachportensis Verco
Figures 15-19

Nucula beachportensis Verco, 1907: 31, pl. 27, fig. 3.

HOLYTYPE. — A specimen from 73 m, off Beachport, South Australia, (SAM D. 11310).

PARATYPES. — See under "Discussion."

DIAGNOSIS: A *Nucula* of middling size, triangularly ovate in outline, with an almost straight posterior margin. Outer shell surface either smooth or with weakly developed, keeled concentric ribs which occasionally are notched by the radial shell structure. Of the known species *Nucula pusilla* Angas comes closest, but *N. beachportensis* is larger, less ventricose, with a very short posterior part, a relatively longer and almost straight posterior margin and, in adult specimens, a chondrophore that projects less beyond the hinge plate and that is more forwardly directed. *N. beachportensis* very probably lives at greater depth, and *pusilla* in rather shallow water.

DESCRIPTION: valve fairly solid, rather shallow, triangularly ovate in outline, posterior part somewhat depressed. Dorsal margin weakly curved, almost linear near the beak, passing into posterior margin either with a distinct angle or gradually. Posterior margin almost straight, descending vertically from the posterodorsal angulation, or when there is no such angulation, slanting backwards directly from beneath the umbo, or intermediate. Dorsal margin anteriorly shading off into anterior margin, which is nearly straight. Posteroventral angle not sharp, but yet distinct, ventral margin broadly rounded — though straighter posteriorly — and gradually extending into anterior margin. Exteriorly, embryonic shell with microscopic pits, interdissoconch smooth, dissoconch either smooth with some more or less pronounced growth lines on anterior, posterior and ventral areas, or with additional sculpture of weak, irregular, keeled concentric riblets. Radial shell structure distinct on median area, most conspicuous in concentrically ribbed specimens in which shell surface and even ribs may show faint radial lines. Shell colour whitish, sometimes with yellowish concentric zones (possibly an artefact). Periostracum light olive green. Hinge parts not very heavy, with up to about 15 anterior and 9 posterior V-shaped secondary teeth. Anterior teeth row extending over chondrophore, not reaching posterior teeth row. Chondrophore not very salient, oblique, strongly forwardly directed. Adductor muscle scars and pallial line often indistinct. Ventral margin minutely crenulated by radial structure.

MEASUREMENTS: The holotype (figs 15-17) has an embryonic shell length of about 0.22 mm, an interdissoconch length of about 0.75 mm, a valve length of 5.74 mm, a valve height of 4.97 mm and a valve section of 1.44 mm. (The measurements given by Verco (1907) and copied by Cotton and Godfrey (1938), i.e. length 4.9 mm and umbo-ventral distance 4.6 mm do not apply to the only specimen indicated as "Type" by Verco). The largest valve examined has a length of 6.16 mm.

RANGE: Off the coasts of southern New South Wales, Victoria, Tasmania, South Australia and Western Australia (fig. 70).

ECOLOGY: Complete specimens of *Nucula beachportensis,* with an unimpaired periostracum, have been dredged from depths between 146 and 183 m and from 366 m. Dead and mostly worn specimens came from depths between 73 and 570.5 m. Hedley (1911) gives 14°C as the bottom temperature near a collecting locality (4 miles south of Cape Wiles).

HORIZON: Ludbrook (1955) recorded the species from Pliocene layers near Adelaide, South Australia.

DISCUSSION: When describing *Nucula beachportensis* Verco had before him several samples other than the one he indicated as type. These can be referred to as paratypes (Mayr, 1969: 371). Verco (1907) lists his original specimens as follows: "Dredged off Beachport, 40 fathoms, 1 perfect (type), 2 valves; in 100 fathoms, 1; 150 fathoms, 2; 200 fathoms, 1; off Cape Jaffa in 130 fathoms, 1; 300 fathoms, 6; all dead." I think that we may assume that all specimens but the type were odd valves. The collection in the South Australian Museum, where Verco worked, holds the following lots from the cited localities: Dredged off Beachport, 40 fathoms, 1 specimen (holotype: SAM D. 11310); in 150 *and* 200 fathoms (put together), 4 valves (SAM D. 15037); in 200 fathoms, 9 valves (SAM D. 15034). Off Cape Jaffa in 130 fathoms, 1 valve (SAM D.15036) and 5 valves (SAM D.15089); in 300 fathoms, 9 valves (SAM D. 15035) and 3 valves (SAM D.15088).

Lot D.15037 contains a label written by Verco which says "COTYPE," but later another specimen has been added and we will probably never know which three out of the four valves are the paratypes. Lots D.15034, D.15036 and D.15088 contain Verco labels reading *"Nucula* 3," obviously written before *beachportensis* was described. Lot D.15089 is labelled by Verco *"Nucula beachportensis* Verco — Duplicates," in which the word *"Nucula"* was obviously written much earlier than the other words, from which it might be concluded that the sample was collected before and identified after the description (where only 1 valve from the concerned locality is mentioned).
If the other lots contain paratypes, which does not seem unlikely because of the labels with Verco's preliminary identifications, it will nevertheless be impossible to indicate the proper specimens (except in D.15036) because of the apparent mutations in the numbers of specimens after the time of Verco's description. The two paratype samples from 40 and 100 fathoms off Beachport have, at the time of this writing, not yet been located.

Apart from the typical form with a distinct posterodorsal "shoulder" (figs 15, 16) quite frequently another form was encountered in which this shoulder was less distinct or even completely reduced. The latter condition results in a posterior margin that seems to run from right beneath the beak. An example of this form, from 260 m, south of Rowley Shoals, Western Australia (WAM 800-71) has been figured (fig. 19). There is no clear geographical or other physical separation between the typical form and this more triangular and possibly slightly shorter form, although the tendency towards the atypical configuration is most marked in Western Australian examples, just like the trend to develop concentric sculpture. The picture is obscured by the occurrence of

intermediates between typical and atypical shells, and further by the fact that one sample may contain different forms.

An outline of a juvenile valve, from 366 m, 30 miles south of Cape Everard, Victoria, has been figured to show the outline change during growth (fig. 18).

SPECIMENS EXAMINED: New South Wales: 6/2 from 294-304 m, 25 miles east of Twofold Bay, 37°27′ S, 150°17′ E, 19-VI-1962, coll. C.S.I.R.O., H.M.A.S. "Gascoyne" (AM C.83135). Victoria: 1 15/2 from 366 m, 30 miles south of Cape Everard, 22-X-1964, coll. "Endeavour" (9/2: AM C.83128; 1 6/2 AM C.83129); 2/2 from off Ninety Mile Beach (NMV F.28122). Tasmania: 1 6/2 from 146 m, off Schontern Island (probably an error for Schouten Island), and 3 from 183 m, 7 miles east of Cape Pillar (put together; SAM D.15031); 1/2 from 570.5 m, 9.5 miles northeast of Tasman Island, 43°12′30″ S, 148°13′45″ E, 24-III-1970, coll. W. F. Ponder, F.R.V. "Penghana" (AM C.83122); 1/2 from Storm Bay (SAM D.15030); 2/2 from Tasmania (TAS E3704). South Australia: 1 from 73 m, off Beachport (holotype; SAM D.11310); 4/2 from 274 and 366 m, off Beachport (SAM D.15037); 9/2 from 366 m, off Beachport (SAM D.15034); 6/2 from 238 m, off Cape Jaffa (1/2: SAM D.15036; 5/2: SAM D.15089); 12/2 from 548 m, off Cape Jaffa (9/2: SAM D.15035; 3/2: SAM D.15088); 7/2 from 183 m, 40 miles south of Cape Wiles, pres. Fisheries Bureau (6/2: AM C.100954; 1/2: RMNH 55093), this sample, and the next, possibly being the ones referred to by Hedley (1911) as from 4 miles South of Cape Wiles; 8/2 from 183 m, 40 miles south of Cape Wiles (SAM D.15038). Western Australia: 1/2 from 132 m, 40 miles west of Eucla (SAM D.15032); 26/2 from 548 m, 120 miles west of Eucla (SAM D.15033); 3/2 from 156 m, west of Bunbury, 33°03′ S, 114°44′ E, 10-VIII-1962, coll. C.S.I.R.O., H.M.A.S. "Gascoyne" (AM C.83132); 7/2 from 260 m, south of Rowley Shoals, 20-XII-1969, coll. "Umataku Maru" (6/2: WAM 800-71; 1/2 RMNH 55094); 8/2 from 266 m, south of Rowley Shoals, about 17°20′ S, 119°15′ E, 20-XII-1969, coll. "Umataku Maru" (WAM 804-71); 2/2 from 250 m, north of Browse Island, 23-XII-1969, coll. "Umataku Maru" (WAM 1150-75).

Nucula torresi Smith
Figures 20-23

Nucula torresi Smith, 1885: 227, pl. 18, figs 9, 9a.

Pronucula voorwindei Bergmans, 1969: 61, figs 1a-c. New synonymy.

LECTOTYPE: A right valve from 247 m, east of Cape York, Queensland, 11°35′25″ S, 144°2′ E, collected 31-VIII-1874, by H.M.S. "Challenger" (BMNH 1887.2.9.2908/1).

PARALECTOTYPES: Two right valves and one left valve, collected together with the lectotype (BMNH 1887.2.9.2908/2).

DIAGNOSIS: A small, stout, rather equilateral *Nucula*, with a blunt umbo and usually with strong rounded concentric ribs and a very small chondrophore that does not project beyond the hinge plate. From *Nucula praetenta* (Iredale) it differs in its concentric ribs and possibly in its smaller size, and from *Nucula saltator* (Iredale) it differs in being shorter and more equilateral, in having a pronounced concentric sculpture over the whole valve beyond the interdissoconch and in the small non-projecting chondrophore.

DESCRIPTION: Valve stout, rather convex, triangular in outline, slightly longer than high. Umbo slightly opisthogyrate, bifid in juvenile valves. Anterior valve part relatively short. Dorsal margin rounded, passing without angulations into an almost straight posterior margin and a weakly curved anterior margin. Posteroventral angulation distinct but not sharp. Ventral margin but slightly curved posteriorly and more rounded

anteriorly. Anteroventral angulation weak, not well marked. Embryonic shell with microscopic pits that under certain light give the impression of tube-like structures just under the shell surface (Bergmans, 1969). Interdissoconch small and smooth. Rest of valve usually with relatively strong, rounded concentric ribs, about as broad as their interstices. Narrow radial riblets between the concentric ribs except on anterior and posterior areas. Periostracum lost in the specimens studied. Shells transparent and white or shining yellowish brown. Chondrophore very small, triangular and oblique, separating the teeth rows but not projecting beyond hinge line. Up to 9 anterior and 6 posterior V-shaped secondary teeth. Only inner boundaries of adductor muscle scars visible. Pallial line not visible. Inner ventral margin denticulated by radial structure, with about 65 denticles in the figured specimen.

MEASUREMENTS: See table 3.

Table 3. Nucula torresi: Measurements, number of teeth and approximate number of concentric ribs.

specimen	length	height	section	e.s.l.	i.d.l.	secondary teeth		concentric ribs
						ant.	post.	
Lectotype	2.86	2.66	1.03			9	6	$\geqslant$20
Paralectotype	2.77	2.38	0.97			9	6	>14
Port Stephens	1.80	1.58	0.58			6	5	14
Roebuck Bay	1.84	1.60	0.58		$\pm$ 0.94	6	5	13
Roebuck Bay	1.64	1.44	0.52	$\pm$ 0.24		6	4	13

RANGE: Along the east coasts of Queensland and northern New South Wales, from Raine Island in the north to Port Stephens in the south, and in northern Western Australia (fig. 71).

ECOLOGY: The species has not been found in beach samples. The Port Stephens specimen was dredged in 44 m, the Roebuck Bay shells in 188 m and the syntypes in 247 m. The Port Stephens specimen is in a good, but not fresh condition, some of the Roebuck Bay valves are in a good condition, and the syntypes are much more worn. The stoutness of the shells might suggest rather rough environmental conditions, such as surf or a coarse-grained substratum, the latter condition extending to greater depths. The syntypes were found in coral sand, for instance (Smith, 1885).

DISCUSSION: Smith (1885) gives as type locality "Station 185" of the Great Barrier Reef Expedition, which position is described by the coordinates cited above. On the original label with the syntypes Raines Island is mentioned as type locality (Raine Island on recent maps), next to "Station 185." The Port Stephens specimen figured here (figs 20-22) agrees in every detail with the lectotype, except that it is in a better condition. Some of the types were locally damaged to the extent that part of the outer shell layer was lacking. This revealed that the radial riblets are the expression of a structure in the middle shell layer. The concentric ribs in the left valve contained in the paralectotype lot are only very weak. The specimens from Western Australia show a smooth median area: the first 5 or 6 ribs and the radial lines fade away here (fig. 23).

SPECIMENS EXAMINED: Queensland: 1/2 from 247 m, near Raine Island, 11°35'25" S, 144°2' E, 31-VIII-1874, coll. H.M.S. "Challenger" (lectotype; BMNH 1887.2.9.2908/1); 3/2 from the same lot (paralectotypes; BMNH 1887.2.9.2908/2). New South Wales: 1/2 from 44 m, Port Stephens (holotype of *Pronucula voorwindei* Bergmans; AM C.67030). Western Australia: 8/2 from 188 m, approximately 135 miles north-west of Roebuck Bay, 17°34' S, 120°22' E, coll. m.v. "Kos 2" (7/2: AM C.88702; 1/2 RMNH 55095).

Nucula praetenta Iredale
Figures 24-26

Nucula umbonata Smith, 1891: 443, pl. 35, fig. 24 (*non* Seguenza, 1877; *nec* Hall, 1883).

Nucula praetenta Iredale, 1924: 184 (*nom. nov.* for *Nucula umbonata* Smith, 1891).

Deminucula praetenta, Iredale, 1931:202.

Tindaria (Deminucula) praetenta, McAlester, 1969: N235, fig. A5-11.

LECTOTYPE: A specimen from 750 m, off Sydney, New South Wales, 34°13'0" S, 151°38'0" E, 13-VI-1874, coll. H.M.S. "Challenger" (Station 164B) (BMNH 89.2.13.12-13/1).

PARALECTOTYPE: A left valve, heavily damaged, from the same sample as the lectotype (BMNH 89.2.13.12-13/2).

DIAGNOSIS: A small, stout, short, triangular, smooth *Nucula,* with a very small but distinct chondrophore and a denticulated ventral margin. Differs from *Nucula torresi* Smith by its smoothness and possibly a larger adult size. Differs from *Nucula saltator* (Iredale) in being less inequilateral, and also by its lack of sculpture and perhaps by a larger adult size. Differs from both *torresi* and *saltator* in both geographical and vertical distribution, as far as the evidence goes.

DESCRIPTION: Valve solid, short, rounded triangular in outline, inflated, with a rather acuminate, incurved umbo. No distinct angles between rounded dorsal margin and weakly curved anterior and posterior margins. Ventral margin anteriorly broadly rounded, posteriorly less curved. Posteroventral angulation rather well marked, anteroventral angulation indistinct. Border and sculpture of embryonic shell obsolete, not distinct. Interdissoconch smooth. Dissoconch smooth, with few slightly pronounced growth lines. Radial structure lines visible in median dissoconch area, but not on anterior and posterior areas. Periostracum very light yellowish brown, thin, smooth. Hinge with 9 anterior and 6 posterior teeth, both teeth rows ending with an additional very small tooth near the umbo. Chondrophore small but distinct, triangular, directed towards anteroventral valve margin, slightly rounded ventrally, hardly projecting beyond hinge plate. Adductor muscle scars ovate, pallial line indistinct. Inner ventral margin finely denticulated by radial structure.

MEASUREMENTS: See table. 4.

RANGE: The only known locality seems to be that of the types, off Sydney, but as *praetenta* probably is a deep water species, an extended range can be expected (fig. 71).

ECOLOGY: The type specimens were dredged from green mud at 750 m. The lectotype is a complete specimen and still bears its periostracum, so it may have lived not far from where it was dredged.

Table 4. Nucula praetenta: measurements and number of teeth.

specimen	length	height	section	e.s.l.	i.d.l.	secondary teeth ant.	post.
lectotype	3.37	3.03	1.04	?0.18	?0.82	9	6
paralectotype	3.00	2.67	0.88				

DISCUSSION: *Nucula praetenta* was described from Station 164B of the "Challenger" Expedition. Due to an error, part of the material said to come from this Station would be from Atlantic origin (Smith, 1891). Apart from one doubtful record (Iredale, 1931) *N. praetenta* has never been collected since the expedition, which by some authors (e.g. Iredale and McMichael, 1962) is used as an argument to assume its Atlantic origin. (The discussions on the material from "Challenger" Station 164B are summarized in my account of *Nucula dilecta dilecta* Smith.) However, the strong affinities of *N. praetenta* with *N. torresi* Smith and *N. saltator* Iredale render Australian origin much more likely. The New Zealand species from shallow waters *Nucula certisina* Finlay, 1930, first figured by Dell (1956 pl. 1, figs 5, 7) is possibly also related.

In 1931 Iredale proposed a new genus, *Deminucula*, solely for *Nucula praetenta*. He based this proposal not on Smith's types, but on "specimens from 800 fathoms, 35 miles east of Sydney, identical with Smith's species", that had been compared with the types, as Iredale writes in a much later paper (1939:234). Surprisingly, in their reference list of marine molluscs of New South Wales, Iredale and McMichael (1962: 4) mention *Nucula umbonata* Smith as one of the assumed Atlantic species, ignoring both Iredale's new specific name *praetenta* – which certainly deserves recognition — and his genus *Deminucula*. Genus and species are simply omitted from the check list proper. The only explanation, apart from an error, is that Iredale's specimens from 800 fathoms (1463 m) had got lost in the meantime.

Regarding the taxonomic position of the genus *Deminucula*, Schenck (1934: 44, pl. 5, figs 3, 3a) caused quite some confusion by figuring and describing *Deminucula praetenta* as a species without a chondrophore. Unfortunately Schenck could not examine the types himself, but had to rely on the information of others (evidently not specialists), who assured him that they could find "no vestige of a chondrophore" in the types, and who provided him with drawings from which the exact hinge configuration is not clear. Hence, Schenck even doubted whether *Deminucula* should be assigned to the family Nuculidae. McAlester (1969: N235), content with Schenck's remarks and copying his misleading illustrations, went so far as to place *Deminucula* in the family Malletiidae Adams and Adams, 1858, as a subgenus of *Tindaria* Bellardi, 1875. In reality, there is no reason to question the placement of this species in the family Nuculidae Gray, as a distinct chondrophore is present (fig. 24).

SPECIMENS EXAMINED: None other than the type specimens.

Nucula saltator (Iredale)
Figures 27-29

Pronucula saltator Iredale, 1939: 231, pl. I, figs 10, 10a.

LECTOTYPE: A left valve from 16 to 22 m, Low Isle, Queensland, 1928-1929, coll. Great Barrier Reef Expedition (AM C.60256).

PARALECTOTYPE: A left valve from the type locality, from the same sample as the lectotype (AM C.78302).

DIAGNOSIS: A small, stout, almost smooth *Nucula,* with blunt umbones, convex valves, concentric sculpture on anterior area only, and a denticulated inner ventral margin. Nearest relatives are *Nucula praetenta* (Iredale) and *Nucula torresi* Smith, from which it differs in being relatively longer, in presence and distribution of concentric sculpture and in having a relatively larger chondrophore.

DESCRIPTION: Valve stout, triangular-ovate, convex. Umbo blunt. Dorsal margin arched, posterodorsal curve not angular, posterior side truncated, posteroventral angulation well marked. No anterodorsal angulation, anterior side slightly curved, anteroventral curve broad, ventral side evenly rounded, somewhat straight posteriorly. Embryonic shell with a pitted outer surface, umbo slightly bifid, interdissoconch smooth and with imperceptible border, rest of valve smooth except for 5 to 9 usually prominent ribs which sculpture the anteroventral area. In the median area a subsuperficial structure of radiating lines is visible, in the lectotype (figs 27-29) 73 near the margin, and not extending, apparently, to anterior and posterior areas. Periostracum lost in the specimens studied. Valve shining white exteriorly, silverish white interiorly. Hinge with up to 6 anterior and 5 posterior V-shaped secondary teeth. Teeth rows separated by a small chondrophore. Chondrophore almost vertical, hardly projecting beyond hinge line, rounded at ventral side. In the lectotype the ventral side of the chondrophore is slightly damaged (fig. 27). Anterior adductor muscle scar partly visible, posterior one and pallial line unapparent. Ventral margin finely denticulated internally by the radial structure.

MEASUREMENTS: See tabel 5.

RANGE: Along the northern part of Queensland's east coast (and possibly also in northern Western Australia) (fig. 72).

ECOLOGY: *Nucula saltator* is known from samples, collected at depths between 7 and 27.5 m. None of the known specimens was collected alive, but it seems not unlikely that the species lives not far offshore, in rather shallow waters. Its relative stoutness suggests exposition to either turbulent water movements (surf), or to a coarse-grained substratum ("coral sand").

DISCUSSION: When Iredale described the species, he must have had more specimens than the two syntypes that resulted from a search in the Australian Museum type collection by Dr W. F. Ponder in 1970. The figures illustrating Iredale's description are of a right valve, while the two syntypes are left valves. Moreover the description speaks of valves with 8 or 9 anterior teeth. On the other hand, the figured valve (Iredale, 1939) measures 1.5 mm in length and has 7 or 8 teeth, which seems an unlikely combination (see table 5). Iredale did not mention the concentric sculpture, though his figure does show it. This sculpture appears to be variable. In some specimens it is very prominent, in others less. In two of the examined specimens it is almost lacking, as it is in the smallest specimen. Partly this may be due to the growth stage of the shells concerned, because the concentric ribs develop only at a certain shell size. All specimens listed below are quite worn. A small valve in rather bad condition from a depth of 128 m at about 200 miles west of Roebuck Bay, Western Australia (AM C.100958), possibly belongs to *saltator,* but more material from that region is needed to check its identity.

Table 5. Nucula saltator: measurements, number of teeth and number of concentric ribs.

specimen	locality	length	height	section	secondary teeth		concentric ribs
					ant.	post.	
lectotype	Low Isle	1.73	1.45	0.56	6	5	5
paralectotype	Low Isle	± 1.73	1.50	0.56	6	5	
largest valve	Albany Passage	1.86	1.59	0.59		5	8-9
smallest valve	Albany Passage	± 1.47	1.18	0.42	6	4	

SPECIMENS EXAMINED: Queensland: 4/2 from 7 to 26 m, Albany Passage, coll. C. Hedley (AM C.36300); 15/2 from 7 to 26 m, Albany Passage, probably also collected by C. Hedley (13/2 AM C.78303; 2/2 RMNH 55097); 2/2 from 16 to 22 m, Low Isle, collected 1928-1929, by the Great Barrier Reef Expedition (lectotype AM C.60256, paralectotype AM C.78302); 4/2 from 27.5 m, Palm Islands, coll. C. Hedley (AM C.10323). (Western Australia: 1/2 from 128 m, approx. 200 miles west of Roebuck Bay, 18°33′ S, 119°08′ E, 7-X-1968, coll. "Espirito Santo"; AM C.100958; identification with reservations.)

Nucula mayi (Iredale)

Figures 33-35

Pronucula decorosa, May (*non* Hedley, 1902), 1915 : 81, pl. 8, figs. 42-42a; May, 1923 : 7, pl. 1, Fig. 1.

Pronucula mayi Iredale, 1930 : 384.

Pronucula cancellata Cotton, 1930 : 224; Bergmans, 1968 : 73-74, pl. 11, figs. 2a-c; Bergmans, 1969 : 62.

LECTOTYPE: A specimen from 16.5 m, Pilot Station, D'Entrecasteaux Channel, Tasmania (SAM D.10114).

PARALECTOTYPES: 5 1/2 from 18.3 m, off Pilot Station, D'Entrecasteaux Channel *and* Union Bay, Tasmania (SAM D.15021).

DIAGNOSIS: A small, delicate, yet relatively solid *Nucula*, sculptured on dissoconch with concentric riblets and in the median area with additional equally fine radial riblets, with a small but distinct chondrophore well separating the teeth rows, and a denticulated ventral margin. Differs from *Nucula covra* Bergmans by its greater size, its distinctly narrower radial riblets, and probably by a different vertical distribution.

DESCRIPTION: Valve small, rather solid, ventricose, truncately ovate in outline. Dorsal margin distinctly curved, posterodorsal angulation marked, posterior margin truncated. Anterior margin slightly curved, gradually passing into dorsal margin. Ventral margin in smaller specimens more evenly rounded, though somewhat straight posteriorly, and in larger shells also straight anteriorly and slightly angulated in the middle. Embryonic shell sculptured with microscopic pits. Interdissoconch smooth but for fine growth lines, dissoconch with fine concentric riblets and with additional radial riblets (about 25 per mm at the ventral margin in the illustrated paralectotype) in the median area. Concentric and radial riblets are of about equal width and so are concentric and radial interstices, resulting in a cancellated median area. Periostracum clearly light brown, thin, shining, smooth. Shell white, transparent. Hinge with a small series of primary teeth near the dorsal margin at either side of the chondrophore, only a few or

none persisting in adult shells. Up to 6 anterior and 4 posterior secondary V-shaped teeth, with tips curving towards the dorsal valve margin. Chondrophore small, hardly exceeding hinge line, directed towards middle of ventral margin, clearly separating the secondary teeth rows. Adductor muscle scars broadly ovate, pallial line indistinct. Ventral margin denticulated by radial shell structure.

MEASUREMENTS: See table 6.

RANGE: Along the coast of New South Wales, up to Port Stephens, and along the coasts of Victoria, east and south Tasmania and South Australia westward to Cape Borda (fig. 72).

ECOLOGY: I have seen specimens taken from beaches and down to a depth of 294-304 m. Perfect shells came from between 14.5 and 73 m, somewhat worn or obsolete shells from beaches and from 73 to 294-304 m. From these data it seems that *mayi* prefers relatively shallow waters.

DISCUSSION: May (1915) appreciated his first find of *Nucula mayi,* from "off Pilot Station in nine fathoms" as a variety of *Pronucula decorosa* Hedley with less pronounced radiating ribs. In 1923, in his index of Tasmanian shells, May still mentions only one locality, namely "off Pilot Station, Channel." The addition "Channel," standing for D'Entrecasteaux Channel (May, 1923 :4), is important, because it fixes May's "Pilot Station" (of which there are several in Tasmania: Miss A. Green *in lit.,* 14-V-1974) and therewith the type locality of *Nucula mayi.*

Coincidentally, in 1930 Cotton and Iredale each based a new species on this sample in the May collection. Iredale's paper was published on the 27th of June, and Cotton's on the 18th of July, so that Iredale's name *mayi* has priority over Cotton's *cancellata.* Iredale was content with May's original illustrations and concise remarks (1915) as a basis for his *Pronucula mayi,* and thus could not indicate a type specimen. He erroneously recorded "Pilot Bay" as type locality, but his reference to the specimens reported on by May (1915) is unequivocal. Cotton, who had May's shells before him, indicated a type specimen (SAM D.10114). I found this specimen to be conspecific — though not identical — with the illustrations by May (1915), and propose here to regard it as lectotype of *Nucula mayi* (Iredale). In the South Australian Museum collection a sample from the former May collection (now SAM D.15021) has been marked *"Pronucula cancellata* Cotton, CO-TYPES". However, these specimens are from "Pilot Station and Union Bay." One may wonder who put the specimens from these two localities together, May or someone after him. If it happened before Cotton studied and described them, the possibility exists that Cotton selected his type from this mixed sample, ignoring the double locality. In this case the type locality would become "Tasmania", or even "Australia", since "Union Bay" cannot be traced (Miss A. Green *in lit.,* 14-V-1974). For the present I must consider the cited type locality of *Nucula mayi* as correct, and leave a further analysis of the question to others.

Before 1930 two samples in the South Australian Museum collection, SAM D.15026 from Gulf St. Vincent and SAM D.15027 from 62 fathoms north-west of Cape Borda, had been labelled by Verco *"Pronucula cancellata* Verco," followed by "sp. n." in the latter sample. We can safely assume that Cotton knew these samples when he described his *cancellata,* and they can almost certainly be regarded as paratypes of *Pronucula cancellata* Cotton.

Table 6. Nucula mayi: measurements and number of teeth.

specimen	length	height	section	e.s.l.	i.d.l.	primary teeth ant.	primary teeth post.	secondary teeth ant.	secondary teeth post.
paratype (drawn spec.)	1.72	1.48	0.62					6	4
Narrabeen	1.60	1.25	0.40			2	1		
holotype	1.50	1.24	0.44	0.22	0.82	2	1	5	4
Off C. Borda	1.50	1.20	0.41		0.82			4	3
Narrabeen	1.44	1.15	0.38						
paratype	1.20	0.98	0.36					4	2

Typical *Nucula mayi* valves are relatively high. Some valves from Collaroy Beach, off Nelson Bay, and Dolls Point are relatively slightly longer and approach small *Nucula pusilla* Angas in their outline. Apart from sculptural differences *mayi* is at once separable from small *pusilla* by its almost symmetrically formed chondrophore.

SPECIMENS EXAMINED: New South Wales: 1/2 from 44 m, Port Stephens (Bergmans, 1969: 62); 2 from off The Old Man Hat Point, Inner North Head, Port Jackson, 1886, coll. J. Brazier (AM C.88709); 2 1/2 from 46-73 m, off Nelson Bay (AM C.100963); 5 from 14.5-18.3 m, Dolls Point, George River, 1961-1962, coll. J. Voorwinde (2 1/2: Collection Van der Slik; 2 1/2: RMNH 52691); 11/2 from 294-304 m, 25 miles east of Twofold Bay, 37°27′ S, 150°17′ E, 19-VI-1962, coll. H.M.A.S. "Gascoyne" (AM C.100957); 1/2 from 149 m, 20 miles south-east of Twofold Bay, 37°26′ S, 150°15′ E, 19-VI-1962, coll. H.M.A.S. "Gascoyne" (AM C.83134). Victoria: 1 dredged from Western Port (SAM D.15022); a series from Corio Bay (NMV F.28113 and RMNH 55098). Tasmania: 1/2 from 56 m, east of Babel Island, 18-I-1968, coll. "Umataka Maru" (TAS E7405); 3/2 from 50 m, east of Flinders Island, 18-I-1968, coll. "Umataka Maru" (TAS E9207); 1 from 16.5 m, Pilot Station (lectotype; SAM D.10114); 5 1/2 from off Pilot Station and Union Bay (paratypes of *Pronucula cancellata* Cotton; SAM D.15021). South Australia: 1/2 from 73 m, off Beachport (SAM D.15028); 6 13/2 from Gulf St. Vincent (SAM D.15026 and D.15029); 1 from 100.5 m, off Cape Borda (SAM D.15024); 1 from 113 m, north-west of Cape Borda (SAM D.15027); 2, and a series, from "South Australia" (SAM D.15023 and D.15025).

Nucula revei n. sp.
Figures 30-32

Pronucula vincentiana, Bergmans (*non* Cotton and Godfrey, 1938), 1968 : 74, pl. 11, figs. 3a-c; Bergmans, 1969 : 62.

HOLOTYPE: A specimen from shell sand, Narrabeen, New South Wales, 1961, coll. J. Voorwinde (RMNH 52697).

PARATYPES: 5/2 from the same sample as the holotype (RMNH 55099); 1/2 from North Head, New South Wales, coll. J. Voorwinde (AM C.83115); 1 from 11-14.6 m, Chinamans Beach, Middle Harbour, New South Wales, coll. J. Voorwinde (AM C.100962).

DIAGNOSIS: A very small species of *Nucula*, with minute radial striae on parts of interdissoconch, radial and concentric riblets on dissoconch, a small chondrophore, and a finely denticulated inner ventral margin. Differs from *Nucula mayi* (Iredale) and *Nucula covra* Bergmans by its radial interdissoconch striae, by the presence of radial riblets on anterior and posterior dissoconch parts and by the relatively small space between chondrophore and secondary teeth rows. From *N. covra* it differs moreover by the narrowness of the radial riblets.

DESCRIPTION: Valve small, relatively solid, somewhat inflated, squarish ovate in outline. Dorsal margin curved, with almost straight anterior and posterior parts. Anterodorsal and posterodorsal angulations marked. Posterior side short, truncated. Posteroventral angulation not sharp but distinct. Anterior side slightly bent, with broad curve passing into rather evenly rounded ventral side. Embryonic shell bifid, with microscopically pitted surface. Interdissoconch with very delicate radial striae, especially on anterior, posterior and ventral areas, and with fine growth lines. Dissoconch with narrow, evenly spaced radial riblets, definitely not corresponding with striae on interdissoconch. These riblets are about as broad as their interstices, extending on anterior and posterior areas, numbering over 70 near valve margin in holotype. The concentric riblets on the dissoconch are somewhat stronger, and less regularly arranged, than the radial riblets. Periostracum unknown, shell whitish. Hinge without distinct primary teeth, dorsal margin not thickened near chondrophore. Up to 6 anterior and 5 posterior secondary teeth, median ones rather crowded and very close to chondrophore. Adductor muscle scars ovate, pallial line indistinct. Inner ventral margin finely denticulated by radial dissoconch structure.

MEASUREMENTS: See table 7.

Table 7. Nucula revei, n. sp.: measurements and number of teeth.

specimen	length	height	section	e.s.l.	i.d.l.	secondary teeth	
						ant.	post.
holotype	1.04	0.90	0.32		0.66	6	4
paratype Narrabeen	±1.3			0.22	0.66		
paratype Chinamans Beach	1.04	0.88	0.32				

RANGE: The known range reaches only from Narrabeen to Middle Harbour, Port Jackson, New South Wales (fig. 71).

ECOLOGY: All known specimens came from beach samples or from depths to 14.6 m. Although, with the exception of the holotype, these specimens are rather worn, *Nucula revei* may well be a shallow water species.

DISCUSSION: When superficially examined specimens of *Nucula revei* are easily taken for representatives of *Nucula mayi* (Iredale). The latter species, however, differs in the distinct restriction of the radial dissoconch sculpture to the median area, a feature shared by a number of other specis dealt with in this paper. This, and the other distinguishing characters of *revei*, its very probable sympatry with *mayi*, and the absence of any intermediate form in the studied samples lead me to consider *revei* as an independent species.

SPECIMENS EXAMINED: Those of the type series detailed above.

Derivatio nominis: The species is dedicated to my friend the Dutch author Gerard Kornelis van het Reve who, during my first years as a student of biology at the Amsterdam University, generously supported my trips in the course of the present study to the Zoologisches Museum at Berlin and the British Museum (Natural History) in London, and who certainly is among the first artists to promote science in this way.

Nucula covra n. sp.
Figures 39-41

HOLOTYPE: A right valve from 183 m, 40 miles south of Cape Wiles, South Australia, VIII-1909, coll. "Endeavour" (AM C.88707).

PARATYPES: New South Wales: 5/2 from 294 to 304 m, 25 miles east of Twofold Bay, 37°27' S, 150°17' E, 19-VI-1962, coll. C.S.I.R.O. Fisheries, H.M.A.S. "Gascoyne", Cruise G2/62, Station 60 (AM C.100955). Victoria: 1/2 from 366 m, 30 miles south of Cape Everard, 22-X-1964, coll. "Endeavour" (AM C.100956). Tasmania: 1 from "off Pilot Station" (at D'Entrecasteaux Channel) or "Union Bay", possible collector W. L. May (SAM D.15020). South Australia: 2/2 from the same sample as the holotype (AM C.100959); 4/2 from 183 m, 40 miles south of Cape Wiles, coll. "Endeavour", possibly also from the same sample as the holotype (2/2 AM C.32040; 2/2 RMNH 55105).

DIAGNOSIS: A small *Nucula* species, with a convex shell, a radial shell structure which may form broad radial ribs on its exterior, and with two rows of distinct primary teeth persisting in adult shells. Secondary teeth few. Inner ventral margin denticulated. From *Nucula decorosa* (Hedley) it differs in being smaller, more convex, less equilateral, in the extension of its radial structure beyond the median area to the anterior and posterior areas, in the possession of well developed primary teeth, and in its relatively less projecting and smaller chondrophore. From *Nucula mayi* (Iredale) it differs in its relatively broader radial ribs, when these are present, its primary teeth configuration, and by greater distances between chondrophore and secondary teeth rows.

DESCRIPTION: Valve small, convex, quadrately ovate in outline. All margins rather rounded, passing into one another without sharp angulations. Posterior side somewhat truncated. Embryonic shell bifid and with granular surface. Interdissoconch smooth. Rest of valve with a very distinct radial prismatic structure, subsuperficial in solid shells but inducing radial ribs on the exterior of thinner shells (about 18 per mm at the ventral margin in the holotype). Thinner shells also tend towards featuring pronounced growth lines, which in combination with the radial ribs more or less cancellate the shell surface. Periostracum unknown, shells white. Chondrophore small, triangular, hardly projecting beyond hinge plate. Up to 5 anterior and 3 posterior V-shaped secondary teeth. Next to these two rows of very small, vertical primary teeth, one row at either side of the chondrophore. These primary teeth seem to arise from the inward turned outer dorsal valve margin rather than from the actual hinge plate, and are difficult to trace in worn specimens, where they may look like mere crenelations. There are up to 5 or 6 anterior and 4 posterior primary teeth. Adductor muscle scars and pallial line not obvious. Inner ventral margin and adjoining parts of anterior and posterior margins coarsely crenulated by the radial structure.

MEASUREMENTS: See table 8.

RANGE: From Twofold Bay in New South Wales along the coast of Victoria, including Tasmania, to Cape Wiles in South Australia (fig. 71).

ECOLOGY: Known collecting depths range from 183 to 366 m. None of the known specimens was collected alive or fresh, but as *Nucula covra* has never been encountered in beach samples or samples from lesser depth, the species probably lives in rather deep waters. The Tasmanian specimen (SAM D.15020) forms part of the "co-types" series of *Nucula mayi* (Iredale) (SAM D.15021). See for the uncertainty about its provenance the discussion of this species.

Table 8. Nucula covra n. sp.: measurements and number of teeth.

specimen	length	height	section	e.s.l.	i.d.l.	primary teeth		secondary teeth	
						ant.	post.	ant.	post.
holotype	1.36	1.20	0.44	0.28	0.80	4-5	4	3	2
SAM D.15020	1.58	1.40	0.50	0.26	0.66			3	3
RMNH 55105	1.48	1.38	0.54	0.28	0.80			4	3
AM C.100956	1.26	1.16	0.44	0.26	0.64	4-5	⩾3	3	2
AM C.100955	1.12	0.96	0.34	0.26	+ 0.66			3	2

DISCUSSION: In the material of *Nucula covra* covered in this study two forms can be recognized that differ in some morphological aspects and in geographical distribution. The specimens from the type locality, 40 miles south of Cape Wiles, are relatively solid, have less pointed umbones, more rounded outlines, no real sculpture, embryonic shell lengths of 0.28 mm and interdissoconch lengths of 0.80 mm. The valves from off Twofold Bay, off Cape Everard and (probably) Tasmania are thinner, have more pointed umbones which are more distinctly bifid, more angular outlines, radial ribs on the dissoconch, pronounced growth lines which in combination with the radial ribs more or less cancellate the shell exterior, embryonal shell lengths of 0.26 mm and interdissoconch lengths of 0.66 mm. Moreover the primary teeth are more narrowly set. In short, the specimens from the southern coast of eastern Australia are more delicately built than the South Australian specimens.

The placement of the species in the genus *Nucula*, in spite of its seemingly aberrant hinge formation, seems justified by the observed presence of primary teeth-like structures in other small species of *Nucula*, e.g. *N. pusilla* Angas and *N. australiensis* (Thiele).

A closely related form from outside Australia seems to be the New Zealand species *Pronucula tenuis* Powell, 1927. This has been collected off Puysegur Point, south-west Otago, at Snares Island and off Leeward Islands, Antipodes, at depths ranging from 27.5 to 315 m (Powell, 1927; 1937; 1955). The holotype of this species, as described and figured by Powell, agrees in many respects with *Nucula covra* from southern east Australia. The main difference appears to be the form and position of the chondrophore, which in *Pronucula tenuis* is larger, not triangular and distinctly projecting beyond the hinge line, and situated nearer the exterior and the posterior side of the valve. I do not wholly

exclude the possibility that the results of future collecting and study will show that *Nucula covra* and *Pronucula tenuis* are actually conspecific. As, in my opinion, *Pronucula tenuis* Powell is clearly a *Nucula* species, th specific name would than be *Nucula covra, Nucula tenuis* being preoccupied (Montagu, 1808).

SPECIMENS EXAMINED: The type series as detailed above.

Derivatio nominis: The name *covra* is formed by the initials of the late Dr. C. O. van Regteren Altena, former Curator of the Mollusca Department of the Rijksmuseum van Natuurlijke Historie at Leiden, The Netherlands, and during his life leading Dutch malacologist. Dr. van Regteren Altena died on the 23rd of December, 1976, when this study had long been completed. His kind help in many ways has been an indispensable support to my debut in the malacological field.

Nucula decorosa (Hedley)
Figures 42-44

Pronucula decorosa Hedley,1902: 290, fig. 39; Bergmans, 1968: 73, pl. 11, fig. 1a-c.

HOLOTYPE: A specimen from 115-138 m, off Port Kembla, New South Wales, collected 18-III-1898, by the "Thetis" (AM C.12309).

PARATYPES: 5 single valves from the same sample as the holotype (AM C.12309).

DIAGNOSIS: *Nucula decorosa* is distinguished by its tendency towards an equilateral outline, its broad radial ribs and the spacial setting of the hinge components. Its nearest relative seems to be *Nucula covra* Bergmans, from which it differs by its larger measurements (to be checked with the interdissoconch lengths: tables 8 and 9), its peculiar periostracum (though the periostracum of *N. covra* is not known yet), its restricted radial sculpture and its chondrophore which projects further beyond the hinge line and is farther from the first posterior tooth.

DESCRIPTION: Valve moderately solid, not very convex, quadrately ovate in outline. Dorsal margin weakly and evenly curved, anterodorsal and posterodorsal angulations indistinct, posterior side short and somewhat truncated, anterior side almost straight. Ventral side broad and rounded, straighter posteriorly. Posteroventral curve gradual, anteroventral curve broad. Embryonic shell with a granularly structured median outer surface, and a narrow smooth border. Interdissoconch smooth but for some weak growth lines. Rest of valve with relatively broad radial ribs (about 45 in the figured paratype valve, length 2.45 mm) and concentric striae, possibly growth lines. Radial ribs restricted to median area, though an occasional indistinct rib may be observed on anterior or posterior area, concentric striae covering whole valve beyond interdissoconch. Shell white to transparent white, covered by a light brown periostracum, that features rows of tubiform projections on the radial ribs, which rows may continue on the interdissoconch. Hinge with subtriangular chondrophore, which distinctly projects beyond the hinge plate, and is separated from both secondary teeth rows by relatively large toothless hinge plate areas. Anterior teeth row with up to 7 teeth, posterior row with up to 5 teeth. Adductor muscle scars and pallial line indistinct. Ventral margin crenulated by the radial ribs.

MEASUREMENTS: See table 9.

RANGE: New South Wales, from Laurieton to Twofold Bay near the Victorian border; probably also in Victoria and perhaps Tasmania. Hedley (1911) recorded *N. decorosa* from south of Cape Wiles, South Australia. In Western Australia off Eucla (fig. 72). The specimens recorded as this species by Cotton (1930) from MacDonnell Bay, South Australia, are in fact *Rumptunucula vincentiana* (Cotton and Godfrey), discussed in the present paper. I have not seen his specimens from 120 miles west of Eucla, mentioned in the same paper, and cannot evaluate this identification.

Table 9. Nucula decorosa: measurements and number of teeth.

locality	length	height	section	e.s.l.	i.d.l.	secondary teeth	
						ant.	post.
off Port Kembla (figured paratype)	2.45	1.91	0.64			6	4
off Sydney	2.93	2.44	0.77	0.34	1.18	7	5
20 miles S.E. of Twofold Bay	2.47	2.06	0.67	0.31	1.22	7	5
off Nelson Bay	2.26	1.90	0.59	0.32	1.06		
	1.76	1.32	0.31			3	2
off Eucla	1.53	1.18	0.39	0.33	1.22	4	2

ECOLOGY: Live specimens have been collected at depths of 46 to 137 m, dead specimens not much beyond this range, as far as I have seen. The types were taken from a sample of "mud and pebbles," at a distance of 5 to 8 miles from the mainland coast. *Nucula decorosa* has not been found on or near beaches.

DISCUSSION: In damaged specimens the shell structure is sometimes revealed. The contact surface between outer and middle shell layers is comparable to that described for *Nucula placentina* (Lamarck) by Taylor, Kennedy and Hall (1969). The prismatic structure that causes tangential projections of the outer layer into the underlying middle layer seems also responsible for the radial ribs covering the exterior of the outer layer. The light breaking effect of the radial prismatic structure is distinct, and helps in determining where the radial rib sculpture exists and where not. It is not known whether this prismatic radial structure exists in those areas of the valve where radial ribs are lacking. According to Dr. J. D. Taylor, London (VII-1971, *in verbis*), it is very unlikely that it would not.

The characteristic periostracum is best studied when the shell is immersed in water. It seems to adhere to dead shells of this species longer than in some other *Nucula* species, and when present it obscures the borders between embryonic shell and interdissoconch and between the latter and the rest of the valve.

For this reason the measurements given in table 9 for embryonic shell length and interdissoconch length are possibly not exact.

SPECIMENS EXAMINED: New South Wales: 7 from 73 m, off Laurieton (RMNH 55100); a sample from 146 m, 22 miles east of Narrabeen, probably collected 7-VI-1906 by H.M.C.S. "Miner" (BMNH 1907.9.10.141); 1 from 46 to 73 m, off Sydney (RMNH 55101); 3 from 46 to 73 m, off Nelson Bay (RMNH 55102); 1/2 from 64 m, off Cronulla, 6-XI-1963, coll. C.S.I.R.O. Fisheries "Benthos" (RMNH 55103); 1/2 from 73 m, off Cronulla, coll. J. McIntyre (AM C.83121); 3/2 from 80 m, off Cronulla, 1966, coll. C.S.I.R.O. Fisheries (RMNH 52692); 3/2 from 115 to 138 m, off Port Kembla, 18-III-1898, coll. "Thetis" (paratypes, AM C.12309); 1/2 from Gerringong, coll. R. Etheridge (AM C.7202); 2/2 from 149 m, 20 miles southeast of Twofold Bay, 37°26′ S, 150°15′ E, 19-VI-1962, coll. C.S.I.R.O.

Fisheries, H.M.A.S. "Gascoyne", Cruise G2/59/62 (AM C.100953). Western Australia: 1 3/2 from off Eucla, 33°20' S, 128°45' E, 5-VII-1962, coll. C.S.I.R.O. Fisheries, H.M.A.S. "Gascoyne", Cruise G2/62, Station 96 (RMNH 55104)

Nucula australiensis (Thiele)
Figures 55-58

Pronucula australiensis Thiele, 1930: 589, pl. 4, fig. 69.

HOLOTYPE: A specimen from 14.5 to 18 m (mud and algae), Cockburn Sound, Western Australia, collected 30-IX-1905 by W. Michaelsen and R. Hartmeyer (ZMB 67669). Holotype by monotypy.

DIAGNOSIS: A small but quite solid *Nucula* species, trapezoid ovate in outline, with relatively broad concentric ribs and a smooth inner ventral margin. Differs from *Nucula papuensis* Bergmans by its much broader concentric ribs and from *Nucula brongersmai* Bergmans by its larger size and its concentric ribs and, in most specimens, by itslack of visible radial structure or sculpture. Differs from both these species by its known geographical range.

Table 10. Nucula australiensis: measurements and number of concentric ribs and secondary teeth, Holotype measurement from the original description (Thiele, 1930).

locality	length	height	section	approx. number of concentric ribs	e.s.l.	i.d.l.	secondary teeth ant.	secondary teeth post.
Gulf St. Vincent ')	1.98	1.76	0.83	± 32	0.22	± 0.80	8	4
Monte Bello Island	1.88	1.61	0.51	21			8	5
Garden Island ')	1.61	1.41	0.50	16			6	4
Bandicoot Bay	1.53	1.33	0.44	19	0.23	0.78	7	3
Monte Bello Island	1.43	1.25	0.43		0.22	0.78	7	4
Cockburn Sound '')	1.4	1.1		17			7	4
Yardie Beach	1.25	1.06	0.39	14	0.22	0.78		
200 miles W of Roebuck Bay	1.10	0.94	0.33	16	0.21	0.75	5	3

') Figured valves.
'')Holotype.

DESCRIPTION: Valve quite solid, moderately convex, trapezoid ovate in outline. Dorsal margins weakly curved, posterodorsal angulation rounded but marked, anterodorsal curve gradual, although in some specimens more angular than in the figured valve from Careening Bay, Western Australia (figs 55-57). Posterior side truncated, ventral side evenly or less regularly rounded, anteroventral curve broad, anterior side almost straight. Embryonic shell weakly bifid (that is, with two slightly elevated umbonal areas), with surface of central part granularly structured, otherwise smooth. Interdissoconch smooth, rest of valve with relatively broad concentric ribs, running into one another on anterior and posterior areas of valve. Traces of a very

delicate radial structure or sculpture sometimes present on interdissoconch and rest of valve. Shell white, periostracum thin, smooth, transparently light brown to greenish. Hinge parts moderately solid. Secondary teeth V-shaped, 8 in anterior and 5 in posterior teeth row in largest specimen. One or two primary teeth at either side of chondrophore. Chondrophore projecting beyond hinge line, with rounded or more angular ventral side. Adductor muscle scars oval, visible in fresh specimens, mantle line not traceable. Inner ventral margin smooth.

MEASUREMENTS: See table 10.

RANGE: Gulf St. Vincent, probably along the South Australian and southern Western Australian coast, and from Cockburn Sound along the Western Australian coast northward to Roebuck Bay, including islands within the Continental Shelf boundary (fig. 73).

ECOLOGY: *Nucula australiensis* is possibly a sublittoral species. Most specimens were collected at or near beaches (0-18 m). Among these were fresh to fairly well preserved specimens. The only specimen from greater depth AM C. 88701 from 128 m, 200 miles west of Roebuck Bay, was not fresh when collected.

DISCUSSION: Thiele (1930) mentioned as type locality just Cockburn Sound. From the label with the type specimen I learned that it had been collected at Station 48 of the Expedition by Michaelsen and Hartmeyer, the position of which, as cited above, was published in the itinerary of this Expedition (Michaelsen and Hartmeyer, 1907).

The anterodorsal part of the right valve of the holotype was lacking. Altogether 37 specimens could be studied. In only two of these was the radial structure or sculpture, mentioned in the description, bserved (AM C. 88701 and SAM D.15090). The fact that not the holotype, but another specimen has been figured, is due to my short and unplanned stay in East-Berlin, where I only had time and equipment to make sketches and notes concerning the holotype specimen. All other specimens of *N. australiensis* listed below have been identified with the help of these.

One figured valve (figs 55-57) is from Careening Bay, Garden Island, which is not very far from the type locality. The other figured valve (fig. 58), the largest known specimen, is from Gulf St. Vincent. The locality suggests that it might represent a link between *N. australiensis* and the undoubtedly related *N. brongersmai,* described hereafter. Its well developed radiating lines on interdissoconch and adjacent anterior and posterior areas of the dissoconch support this idea. But considering both as conspecific would leave us with the inherent assumption that all known specimens of the very small *brongersmai* are juveniles. This is far from likely, since the collecting localities of *brongersmai* comprise some of the malacologically best known of Australia, and yet specimens approaching the size range of *australiensis* have never been collected. I therefore prefer the treatment as proposed here, and to await the results of future collecting before commenting on the actual relation between the two forms.

SPECIMENS EXAMINED: South Australia: 1 from Gulf St. Vincent (SAM D.15090); Western Australia: 1 from 14.5 to 18 m (mud and algae), Cockburn Sound, 30-IX-1905, coll. W. Michaelsen and R. Hartmeyer (holotype: ZMB 67669); 1 2/2 from base of Skippy Rock, Careening Bay, Garden Island, 16-I-1965, coll. S. Slack-Smith (WAM 1147-75; left valve of complete specimen figured); 4 2/2, from Yardie Beach, North West Cape, 9-X-1969, coll. F. Plant (WAM 1149-75); 1 2/2, found high up on sheltered intertidal sandflats, Bandicoot Bay, 20°52′ S, 115°19′ E, 31-VIII-1966, coll. U.S.N.M. "Barrow I", W.A. Exp. 1966 (WAM 807-71); 2 20/2 from Monte Bello Island, 18-IX-1945, coll. G. P. Whitley (2 18/2 AM C.83125; 2/2 RMNH 55106); 1/2 from 128 m, approximately 200 miles west of Roebuck Bay, 18°33′ S, 119°08′ E, 7-X-1968, coll. m.v. "Esperito Santo" (AM C. 88701).

Nucula papuensis n. sp.
Figures 52-54

HOLOTYPE: A single right valve from between 7 and 26 m (4-14 fathoms), Albany Passage, north-east Queensland, possibly collected by C. Hedley (AM C.100961).

PARATYPES: 8/2 from 9-18 m, Hope Island, Queensland (approx. 15°43′ S, 145°24′ E), presented (and probably collected; see Hedley, 1912: 131) by C. Hedley (AM C.29678); 9/2 from a seaweed dredge in 12.8 m, Amazon Bay, Milne Bay District, Papua, collected 13-IX-1948 by C.S.I.R.O. Fisheries (7/2: AM C.83101; 2/2: RMNH 55107).

DIAGNOSIS: A small species of *Nucula*, combining sculpture of fine concentric ribs (not on embryonic shell and interdissoconch) and a smooth inner ventral margin. Distinguished from its nearest relatives, *Nucula australiensis* (Thiele) and *Nucula brongersmai* Bergmans, by the narrowness and greater number of its ribs *(australiensis)* and by its proportions and concentric sculpture *(brongersmai)* and by its geographical range (both species).

DESCRIPTION: Valve not very convex, moderately solid, trapezoid ovate in outline. Dorsal margin weakly curved, posterior side truncated, anterior side only weakly rounded, ventral side evenly rounded but for an almost straight posterior section. Anterodorsal, posterodorsal and posteroventral angulations rather distinct. Embryonic shell distinctly bifid in some younger shells, with a pitted appearance of the surface in the central area. Interdissoconch smooth. Rest of valve covered by rather fine and closely set concentric ribs. A very delicate structure or sculpture of radiating lines is visible on anterior and posterior areas of both interdissoconch and rest of valve. The shell is white or with a very weak brownish tinge. The epidermis is abraded in all the types. Hinge plate relatively broad, with 7 anterior and 4 posterior, V-shaped secondary teeth in the largest specimen and one primary tooth at either side of the chondrophore. The chondrophore in the holotype is slightly damaged at its ventral margin, but in the paratypes it is relatively hardly larger, with a somewhat rounded ventral side, and projects beyond the hinge line. Adductor muscle scars and pallial line not visible. Inner ventral margin smooth.

MEASUREMENTS: See table 11.

RANGE: From the limited material collected thus far it may be concluded that *Nucula papuensis* occurs at either side of Torres Strait, and probably along or near the coasts of the islands in this strait. Hope Island is the southernmost locality along the eastern Queensland coast (fig. 73).

ECOLOGY: Although none of the known specimens was collected alive or freshly dead, the species probably does not live much beyond the depth range of 7 to 26 m from which it was dredged, because the depths around the collecting localities hardly surpass 26 m.

SPECIMENS EXAMINED: The type series as detailed above.

Nucula brongersmai n. sp.
Figures 59-61

Pronucula pusilla, Bergmans (*non* (Angas, 1877)), 1968: 76, pl. 12, figs 4a-c; Bergmans, 1969: 63.

HOLOTYPE: A single right valve, collected at Primrose Sands, Tasmania, 25-III-1967, by E. Aves (TAS E5373).

PARATYPES: New South Wales: 3 39/2 from shell sand, Narrabeen, 1961, coll. J. Voorwinde (RMNH 59696); 4/2 from shell sand, Narrabeen, coll. J. Voorwinde (Collection Van der Slik); 4/2 from 3.6 to 7.3 m, Fairlight, Port Jackson, coll. J. Voorwinde (AM C. 83119); 1 from 9 m, off Bottle and Glass Rocks, Port Jackson (AM C.100960); 2 from 3.6 m, east side Sow and Pigs Reef, Port Jackson (near the rocks, rocky bottom), 1865, coll. J. Brazier (AM C.100970); 1 from 11 to 14.6 m, Chinamans Beach, Middle Harbour, coll. J. Voorwinde (AM C.83114); 1 from algae, Balmoral, Sydney Harbour, 19-I-1969, coll. W. F. Ponder and J. Voorwinde (AM C.73217); 3/2 from Collaroy Beach, coll. J. Voorwinde (AM C.83118). Victoria: 1 2/2 from Corio Bay, ex-collection J. H. Gatliff (NMV F28114). Tasmania: 1/2 from Tinderbox, 12-IV-1967, coll. E. Aves (TAS E5469).

DIAGNOSIS: *Nucula brongersmai* is distinguished at once from sympatric *Nucula* species by the combination of its minute size, sculpture of peculiar radial striae (extended to interdissoconch) and smooth inner ventral margin. From its closest relatives, *N. australiensis* (Thiele) and *N. papuensis* Bergmans, *brongersmai* differs in being smaller, in the possession of a usually well developed sculpture of radial striae and by the absence of concentric riblets. It also has a different geographical range.

DESCRIPTION: Valve moderately convex, trapeziod ovate in outline. Dorsal margin weakly curved and in a number of specimens with a weak median angulation at the level of the chondrophore. Posterior side rather truncated, posterodorsal and posteroventral angulations rather distinct. Ventral side evenly rounded but for an almost straight posterior part. Anterior side almost vertical and only weakly curved, tending to be straight in the largest specimens.

Anteroventral and anterodorsal angulations indistinct. Valve moderately solid. Embryonic shell umbo bifid, surface with granular appearance. Rest of valve, including interdissoconch, with more or less elevated lines of growth and covered by numerous very delicate radiating striae. Interdissoconch border not distinguishable in most specimens. Shell transparent, whitish. Epidermis thin, light green to light greenish brown. Hinge with up to 7 anterior and 4 posterior V-shaped secondary teeth. A minute projection (primary tooth?) at either side of the chondrophore. Chondrophore triangular, with rounded ventral margin projecting beyond hinge line. Adductor muscle scars (visible in some specimens: Bergmans, 1968, fig. 4a) almost equal, ovate. Pallial line not visible. Inner ventral margin smooth.

MEASUREMENTS: See table 12. In one specimen from Fairlight, Port Jackson (AM C.83119) the interdissoconch length appeared to be about 0.66 mm, but this measurement should be considered with reservation. The specimen from Tinderbox (TAS E5469) is the largest known specimen.

RANGE: From Narrabeen in New South Wales southwards and westwards to Corio Bay in Victoria, and in south-eastern Tasmania (fig. 73).

ECOLOGY: Well preserved or fresh *Nucula brongersmai* have been collected on beaches and at a depth of 3.6 to 9 m. Worn specimens are known from beaches and from depths to 14.6 m. As the species was never found in deeper waters, its habitat is probably in shallow sublittoral waters.

DISCUSSION: The conchological variation is restricted to the outer shell sculpture. Growth lines may be rather pronounced in some specimens and hardly affecting the shell surface in others. They never tend to resemble riblets, however. The radial striae as a rule are most distinct on anterior and posterior areas; on the rest of the valve they can be as distinct as almost obscure, especially on the median area. The species bears a great likeness to both *australiensis* and *papuensis*, but as yet these species seem to be rather widely separated geographically, and reflections on possible closer relations between them and *brongersmai* would at present be mere speculations.

Table 11. Nucula papuensis, n. sp.: measurements and number of concentric ribs and secondary teeth; paratypes from Amazon Bay.

specimen	length	height	section	e.s.l.	i.d.l.	approx. number of concentric ribs	secondary teeth	
							ant.	post.
holotype	1.39	1.21	0.44		0.76	35	7	4
paratype	1.18	1.02	0.37		0.69	23	5	3
paratype	1.14	0.94	0.33	0.20	0.75	20	4	3
paratype	1.04	0.87	0.29	± 0.22	0.73	16	4	3

Table 12. Nucula brongersmai, n. sp.: measurements and number of teeth.

specimen	locality	length	height	section	e.s.l.	secondary teeth	
						ant.	post.
holotype	Primrose Sands	1.07	0.91	0.30	0.26	7	4
paratype	Fairlight, Pt. Jackson	0.96	0.81	0.28	0.20	5	4
paratype	Collaroy Beach	0.94	0.78	0.28	0.23	4	3
paratype	Tinderbox	1.23	1.05	0.35		7	4
paratype	Balmoral	1.03	0.85	0.30	0.20	4	3

Derivatio nominis: I dedicate this smallest of all known Australian *Nucula* species to professor Dr L. D. Brongersma, former director of the Rijksmuseum van Natuurlijke Historie, Leiden, who so often encouraged me during the initial stages of my biology studies.

Nucula dilecta dilecta Smith

Figure 66

Nucula dilecta Smith, 1891: 442-443, pl. 35, fig. 23.

LECTOTYPE: A specimen from 750 m, off Sydney, New South Wales, 34°13'0" S, 151°38'0" E, 13-VI-1874, coll. H.M.S. "Challenger" (Station 164B) (BMNH 89.2.13.22-30/1).

PARALECTOTYPES: 8 (or 7 2/2) specimens from the same sample as the lectotype (BMNH 89.2.13.22-30/2).

DIAGNOSIS: A medium sized, rather ventricose, oval-shaped, smooth species of *Nucula*, with a relatively long posterior area, a hardly oblique chondrophore and a smooth inner margin. It cannot be confused with any other sympatric *Nucula* species. Subspecific differences in outline and hinge configuration.

DESCRIPTION: Valve somewhat ventricose, with two very weak depressions radiating from umbo towards margins, one just above anteroventral and one just above posteroventral curve. Valve of medium thickness, truncately ovate in outline. Dorsal margin almost straight anteriorly, weakly curved posteriorly, with broad curves passing into short and rather straight anterior and posterior margins. Posteroventral angulation distinct. Ventral margin broadly and evenly curved. Anteroventral curve broad. Embryonic shell border not to be traced with certainty, surface microscopically pitted. Interdissoconch smooth, border not easily discernible. Dissoconch smooth but for some pronounced growth lines, especially on anterior and posterior (and occasionally extreme ventral) areas. Periostracum thin, shiny, yellowish to greyish olive green, covering inner valve margin, in larger specimens obsolete in umbonal region. Chondrophore not very oblique, with a rounded ventral margin. Secondary teeth rows starting lateral from chondrophore, with up to 9 anterior and 7 posterior, rather slender teeth. Adductor muscle scars and pallial line indistinct.

MEASUREMENTS: See table 13.

RANGE: The only known locality of the subspecies *dilecta* is the type locality, i.e. off Sydney (fig. 74), but as it is a true deep water species, with subspecies in South Australian and eastern Indonesian waters (and possibly also in New Zealand: see under "Discussion"), a more extended range may be expected. Cotton (1930: 225) reports on *Nucula dilecta* from a depth of 91-128 m, at Port Arthur, but the sample from this locality so named by him (SAM D.15092) does not contain this species, but another, obliquely chondrophored *Nucula*, not discussed in this paper.

Table 13. Nucula dilecta dilecta: measurements and number of teeth.

specimen	length	height	section	secondary teeth	
				ant.	post.
lectotype	5.67	4.50	1.50	9	7
paralectotype	5.08	3.83	1.33		
paralectotype	3.67	2.71	0.83	6	4
paralectotype	3.29	2.43	0.77	6	5

ECOLOGY: The type series was trawled from green mud (Smith, 1885: 15). The known depth range of the three subspecies recognized here runs from 250 to 959 m. Complete and fresh looking specimens came from depths of 550, 750 and 959 m.

DISCUSSION: The first of the three subspecies to be studied and drawn for this study happened to be *N. dilecta flindersi* (Cotton). Because of the great resemblance I later confined the illustration of *N. dilecta dilecta* to the outline and hinge.

Already in 1891 Smith (p.436) had remarked that a number of specimens said to originate from Station 164B of the "Challenger" Expedition were not Australian but "undoubtedly Atlantic forms", suggesting that some mistake had been made aboard the

"Challenger" in labelling an Atlantic sample as one from Station 164B. As appears from Hedley's first account of this problem (1901), Smith withdrew this opinion a few years later, convinced by Dr J. Murray of the "Challenger" Expedition that no mistake could possibly have been made. Hedley was not convinced, and in 1918 he even attributed the supposed mistake to Murray himself. Hedley and Petterd (1906) were the first to examine an extensive new collection from near this Station, and they could confirm the Australian origin of about half of the species that had been recorded from Station 164B. They decided to await further investigations before determining the origin of those species that had not yet been found again, among which were *Nucula dilecta* Smith and *Nucula umbonata* Smith, which is treated elsewhere in this paper (as *Nucula praetenta* Iredale). Not much later Hedley (1907: 362) believed he had rediscovered *Nucula dilecta:* "Of common occurrence in the vicinity of the type locality is a *Nucula* which coincides with the account of *Nucula dilecta* and which is accordingly identified as such. But this involves adding *N. dilecta* to the synonymy of *Nucula obliqua,* Lamarck . . . ". In his checklist of 1918 Hedley still sticks to this opinion. If Hedley had known the hinge of the *Nucula dilecta* types, he would not have made this error. I have not seen his *"dilecta"* specimens and thus have no opinion as to where they might belong, but they evidently do not belong to *N. dilecta.* (The holotype of *N. obliqua* Lamarck has been figured by Schenck, 1934, pl. III.) Iredale (1929: 158) disagrees with Hedley (1907), stating that *Nucula dilecta* Smith is easily separable (from *Nucula obliqua* Lamarck) on account of its shape and smaller size. Iredale, too, failed to discuss the obvious hinge differences, and I wonder whether he based his comments on specimens or on Smith's original description and figure. In 1931 Iredale (p. 102) writes of a "deep-water form of *dilecta* from 300 fathoms east of Sydney" (which would be more elongate than the typical form) but later Iredale and McMichael (1962: 4) eliminated *dilecta* from the faunal list of New South Wales, stating that it had not been found since Smith's description and that it "can be assumed to be from the Atlantic." This assumption is no more warranted than the supposition that *dilecta* is Australian, because its Atlantic distribution has never been verified either. Because of the discovery of *Nucula diaphana* Prashad from eastern Indonesia and Western Australia and *Pronucula flindersi* Cotton from South Australia, which in my opinion are only subspecifically distinct from *N. dilecta* sensu stricto, I do not doubt that *N. dilecta* is Australian, and that its types originate from "Challenger" Station 164B. The occurrence of yet another, closely related form, *Nucula strangeiformis* Dell (1956: 9, pl. 1, figs 2, 3), at depths of between 400 and 600 m at various localities in New Zealand waters, supports this conclusion. (In fact, type material of *N. strangeiformis* should be compared to that of *N. dilecta,* because neither the described characters nor the figures of *N. strangeiformis* warrant its recognition as specifically different from *N. dilecta* sensu lato. On the contrary, it strikingly agrees with the nominate form.)

In his original description Smith states about *dilecta* "pagina interna . . . radiatim minute substriata . . . ". Indeed, faint radiating lines (structure?) may be observed in the valve interior. I found traces of what is likely to represent radial structure on the exterior of the holotype of *Nucula dilecta flindersi* (Cotton) (fig. 62). (Undoubtedly Dell (1956) refers to similar observations in *Nucula strangeiformis* when he somewhat ambiguously describes its interior as "smooth, polished, sculptured with fine radials".)

SPECIMENS EXAMINED: None other than the type specimens.

Nucula dilecta flindersi (Cotton)
Figures 62-64, 68

Pronucula flindersi Cotton, 1930: 225, fig. 3.

HOLOTYPE: A specimen from 550 m, 120 miles west of Eucla, Western Australia, date and collector unknown (SAM D.10116). Holotype by monotypy.

PARATYPES: 6/2 and 4 fragments from the type locality, date and collector unknown (SAM D.1587); 7/2 from 550 m, 120 miles east of Eucla, South Australia, date and collector unknown (SAM D.15086).

DIAGNOSIS: At specific level as for *Nucula dilecta dilecta* Smith. The characters in which it differs from the nominate form and from *Nucula dilecta diaphana* Prashad are described below.

DESCRIPTION: Agrees in most details with nominate form. Differs in that the posterior area is shorter, dorsal margin less curved, anterodorsal and posterodorsal angulations sharper and more distinct, posterior margin more vertical, posterior teeth row shorter, anterior teeth more numerous, hinge plate immediately anterior of chondrophore narrower. From *Nucula dilecta diaphana* Prashad it differs in its longer dorsal margin, its much more vertical posterior margin and its less numerous, less lamelliform anterior teeth. For relation valve length/anterior teeth number in *Nucula dilecta* subspecies see fig. 1. In some specimens of *flindersi* embryonic shell and first stage of interdissoconch opaquely white. Weak traces of radial lines — probably shell structure — on lower posterior side of valve exterior. Periostracum thin, greyish green. In the holotype there are two very small projecting folds on anterior valve side, probably deformations. Up to 10 anterior and 5 posterior teeth.

MEASUREMENTS: See table 14.

RANGE: From 120 miles west of Eucla, Western Australia, eastwards into South Australian waters, 120 miles east of Eucla (see under "Discussion", however) (fig. 74).

Cotton and Godfrey (1938) mention Neptune Islands as the eastern limit of distribution, but I have not seen the sample on which this was based, and cite this locality with strong reservations.

Table 14. Nucula dilecta flindersi: measurements and number of teeth.

specimen	collection	length	height	section	approx. e.s.l.	approx. i.d.l.	secondary teeth	
							ant.	post.
holotype	SAM D.10116	4.04	3.29	1.07	0.27	0.65	10	5
paratype	SAM D.1587	4.07	3.10	1.03			9	5
paratype	SAM D.1587	3.66	2.76	0.83			8	5
paratype	SAM D.1587	2.97	2.28	0.69			7	4

ECOLOGY: The types are all from the same depth, 550 m. The holotype and one series of paratypes (SAM D. 15086) are in excellent condition and probably lived at or not much beyond this depth.

DISCUSSION: Verco wrote the original labels accompanying the three type samples (W. Zeidler *in lit.*, 3-V-1974). He recognized the shells as representatives of a new species and even named them "*Pronucula flindersi* Verco" on the labels, but did not publish his findings. The original holotype label reads "D.10116 TYPE *Pronucula flindersi* 120 miles W. of Eucla 300 fms." Verco's labels with the paratype series read "D.1587 *Pronucula*

flindersi Verco 300 fms. 120 miles W. of Eucla" and "D. 15086 *Nucula* 3 300 fms 120 miles E. of Eucla." (The registration numbers have been added later.) Cotton was the only person to handle the Nuculidae of the South Australian Museum collections after Verco and before the present author (Mrs H. M. Laws *in lit.*, 1-III-1972). When describing the species he overlooked the remarkable difference between the localities of the two paratype series and put both in one bigger tube, adding one general label reading "SA.Mus. D.1587 *Pronucula flindersi* Cotton Cotypes 120 m. W. of Eucla 300 fms.". In the course of the present study the paratype sample from 120 miles east of Eucla has been separated again and registered as SAM D.15086.

Nucula dilecta flindersi does not show variation in shell morphology, as far as the known specimens are concerned. Younger specimens are just a bit more angular in outline, with the radial depressions more distinct, and the anterior valve margin straight (fig. 68). Cotton (1930) claims the species to have concentric ribs, but the few more or less pronounced growth lines can by no means stand as such, although they must be what Cotton referred to. In fact, the outer surface in *flindersi* is polished and smooth as in none of the other small nuculid species treated in this paper (apart from the other two *dilecta* subspecies). Cotton *(loc. cit.)* gave as the difference between *flindersi* and *Pronucula concentrica,* described by him in the same paper and here regarded as a synonym of *Nucula pusilla* Angas, that *flindersi* has concentric ribs over the ventral portion (of the valve), while *concentrica* has its whole valve covered with concentric ribs. It now appears that *flindersi* has no ribs at all, while *concentrica* has at least a smooth interdissoconch. Both Cotton's descriptions and illustrations of *flindersi* and *concentrica* are therefore misleading. The absence of a distinctly visible radial structure and of a denticulated inner ventral margin are better used to distinguish *flindersi* from *concentrica*. The hardly visible radiating lines on the posterior part of the valve exterior in *flindersi* seem to affect the surface, but very soon become worn in dead shells where they can not be traced. In fresh specimens they may even very slightly notch the inner valve margin, so that under a certain angle of light it appears to be somewhat undulating at the level of the radial lines.

Specimens examined: No specimens other than the types.

Nucula dilecta diaphana Prashad
Figures 65, 67

Nucula (Nucula) diaphana Prashad, 1932: 15, pl. I, figs. 3, 4.

SYNTYPES: Three specimens, one type and two paratypes, from 959 m, dredged between Sumba and Flores, Indonesia, 9°3'4" S, 119°56'7" E, 20-IV-1899, coll. "Siboga" (Station 52) (holotype and paratype: ZMA; paratype: ZSI M.13306/2).

DIAGNOSIS: At specific level as for *Nucula dilecta dilecta* Smith. The characters in which *diaphana* differs from the subspecies *dilecta* and *flindersi* are described below.

DESCRIPTION: *Nucula dilecta diaphana* agrees in most details with the nominate subspecies. It differs from this in form of posterior margin, which is less vertical, in number and form of anterior teeth, which are more numerous and more lamelliform, and perhaps by its greater size. From *Nucula dilecta flindersi* it differs by its less vertical posterior margin, its less distinct or even indistinct anterodorsal and posterodorsal angulations, its longer posterior teeth row and its more numerous anterior teeth. There is no real concentric sculpture of very fine, microscopic striae as Prashad (1932) states, these "striae" being merely lines of growth. Up to 16 anterior and 11 posterior teeth.

MEASUREMENTS: See table 15.

RANGE: From between Sumba and Flores, Indonesia, via Browse Island to south of Rowley Shoals, off northern Western Australia (fig. 74).

ECOLOGY: The types of *Nucula dilecta diaphana* were dredged in "Globigerina ooze" on 959 m. These are rather well preserved specimens and probably lived near that depth. The only recently collected Western Australian specimens are mostly rather worn or even obsolete and from lesser depth, 250 to 300 m.

DISCUSSION: Mr. N. V. Subba Rao of the Zoological Survey of India kindly informed me that in the collection of this institution there are two specimens of *Nucula diaphana* Prashad, labelled as paratypes in Prashad's hand (Subba Rao, 12-IX-1975, *in lit.*). As the holotype and one paratype are in the collection of the Zoologisch Museum in Amsterdam there appear to be four types instead of the three mentioned by Prashad in his description (1932). I can not think of a solution to this confusing matter. The Western Australian specimens (and the known representatives of the other two subspecies) are all smaller than the two *diaphana* types in the ZMA collection.

Table 15. Nucula dilecta diaphana: measurements and number of teeth.

specimen	length	height	section	secondary teeth	
				ant.	post.
holotype (ZMA)	8.33	6.67	2.25	16	11
paratype (ZMA)	7.83	6.17	2.20	12	9
WAM 803-71	4.76	3.66	1.41	14	7
WAM 803-71	3.10	2.34	0.83	10	6

The number of anterior teeth in the specimens from Browse Island and Rowley Shoals is relatively larger than in the types. Considering all known representatives of *Nucula dilecta* sensu lato it is suggested that a negative ecological correlation exists between collecting depth and anterior teeth number, in the sense that shells from deeper water bear relatively fewer teeth. More material is needed to verify this phenomenon, which would interfere with the subspecific arrangement as here defined. It is not even unlikely that future collecting will also yield evidence that other differences here considered of taxonomic value are not really that important. After all we may expect a very extended distribution area for a deep water species like *dilecta*, already strongly suggested by the striking resemblance of Indonesian, Australian, and probably also New Zealand forms. We may then also expect an inherent variation of characters, when comparing material from different populations which are more or less isolated vertically and horizontally.

The hinge of the holotype, and outline and hinge of a worn Western Australian specimen (WAM 801-71) have been figured.

SPECIMENS EXAMINED: Western Australia: 1/2 from 260 m, south of Rowley Shoals, 20-XII-1969, coll. "Umataku Maru", UMD 6920 (WAM 801-71); 6/2 from 300 m, south of Rowley Shoals, 20-XII-1969, coll. "Umataku Maru", UMD 6921 (WAM 802-71 and 803-71); 7/2 from 266 m, south of Rowley Shoals, 20-XII-1969, coll. "Umataku Maru", UMD 6926 (6/2: WAM 805-71 and 1/2: RMNH 55108); 1/2 from 250 m, north of Browse Island, 23-XII-1969, coll. "Umataku Maru", UMD 6929 (WAM 806-71). Indonesia: 2 from 959 m, 9°3'4" S, 119°56'7" E, between Flores and Sumba, 20-IV-1899, coll. "Siboga" (holotype and paratype; ZMA).

Nucula species
Figures 36-38

Nucula micans, Bergmans (*non* Angas, 1878), 1968: 78; pl. 12, figs. 6a-c; 1969: 63.

It seems useful to draw attention to this small species which, to judge from its embryonic shell length (about 0.24 mm) and its comparatively high number of teeth, is probably adult or nearly so at a length of 1.18 mm as in the figured specimen. The type of *Nucula micans* Angas, now regarded as a junior synonym of *Nucula pusilla* Angas, possesses a distinct radial shell structure and a correspondingly crenulated inner ventral margin, whereas these specimens do not show any sign of radial structure and have a smooth ventral margin. Moreover, the tooth count is considerably larger than in *pusilla* of the same size (the *pusilla* valve of figs. 9-11 measures 1.94 mm and still has fewer teeth). As the available material is very scarce, and some of it rather worn, I refrain from attaching a specific name to it.

SPECIMENS EXAMINED: New South Wales: 1/2 from shell sand, Narrabeen, 1961, coll. J. Voorwinde (RMNH 54758); 2/2 from Northhead, Sydney Harbour, coll. J. Voorwinde (AM C.83116); 1/2 from 11-14.5 m, Chinamans Beach, Middle Harbour, coll. J. Voorwinde (AM C.83113).

Rumptunucula n. gen.

TYPE SPECIES: *Pronucula vincentiana* Cotton and Godfrey, 1938.

DIAGNOSIS: A genus of the family Nuculidae with the hinge plate interrupted beneath the beak, a sunken chondrophore, and one or more small primary teeth at either side of the resilium between anterior and posterior hinge plate parts. Hinge plate and chondrophore configuration distinguish this genus from all other genera in the family.

DESCRIPTION: Valves longer than high, with a triangularly or squarish ovate outline. Embryonic shell and interdissoconch marked. Shell with radial prismatic structure which may affect the outer dissoconch surface to the extent of radial riblets. Hinge plate interrupted in the middle. Relatively many teeth on anterior hinge plate part, which ends in front to the umbo, and few teeth on posterior hinge plate part, which ends posterior of the umbo. Small primary teeth project from the inner dorsal margin in the hinge plate gap, one or a few at either side of the ligament. Chondrophore sunken into the valve, projecting from the inner valve surface distal of the hinge plate gap and supported by ridges which radiate from the chondrophore over the inner valve surface. Adductor muscle scars ovate, rather long.

Species included: Only the type species.

DISCUSSION: Superficially the only known representative of the new genus here proposed bears much resemblance to *Nucula decorosa* (Hedley), though a better look at the hinge structure at once reveals its position as distant from this and other species of *Nucula*. Traces of a periostracum, preserved in one of the three known specimens, suggest that this might have borne projections similar to those on the periostracum in *decorosa*, while valve outline and style of sculpture also remind one strongly of this species. No really close relatives of *Nucula decorosa* are known, and the same is true for *Rumptunucula vincentiana*. Both species are possibly relatively young, and within the scope of our present knowledge of genera and species of the Nuculidae it seems permissible to envisage a close origin of both taxa. *Nucula decorosa* remained within the limits of the genus *Nucula* Lamarck, 1799, and the off-shoot that eventually gave rise to

Rumptunucula vincentiana crossed these limits. In my opinion *Rumptunucula* is of special interest, since it shows a possible way in which evolution may interfere with so stable a character as the typical *Nucula* hinge configuration.

Derivatio nominis: The prefix *Rumptu* is derived from the Latin verb *rumpere,* meaning to break, or to split, and applies to the broken up hinge plate.

Rumptunucula vincentiana (Cotton and Godfrey)
Figures 48-51

Pronucula vincentiana Cotton and Godfrey, 1938: 38, fig. 7.

HOLOTYPE: A specimen from Gulf St. Vincent, South Australia, date and collector unknown (SAM D.13151).

DIAGNOSIS: A trapezoid ovate, small shell, with relatively broad radial ribs on median area of dissoconch, an anterior hinge plate which tapers towards the umbo, a rather large oblique chondrophore, a broad posterior hinge plate, and a crenulated inner ventral margin.

DESCRIPTION: Valve small, rather inflated, trapezoid ovate in outline, with the greatest height in the anterior part; delicate but not very thin. Dorsal margin slightly and evenly curved, angulations between dorsal and anterior and posterior margins marked but not sharp. Posterior margin short and slightly rounded. Anterior margin long and weakly curved. Ventral margin broadly rounded but for an almost straight posterior part, with broad curvings passing into anterior and posterior margins. Embryonic shell with microscopically pitted outer surface, interdissoconch smooth but for fine growth lines. Dissoconch with some pronounced growth lines (that do not take the shape of riblets), and with radial ribs on its median area; interstices between the ribs rather broad. Radial ribs extending farther on anterior and posterior areas than in *Nucula decorosa* (Hedley). Growth lines most prominent on anterior and posterior extremities. Periostracum light brown. Anterior hinge plate rather long, narrowing posteriorly, extending over chondrophore and ending just before umbo. Anterior secondary teeth up to 9, narrowing with hinge plate, with somewhat curved tips. Posterior hinge plate relatively short and broad, only narrowing between its first secondary tooth and umbo and ending posterior of umbo. Up to 3 posterior secondary teeth. Chondrophore solid, rectangular, obliquely projecting into the valve towards anterior part of ventral margin and supported by 4 or 5 ridges on the valve interior. Posterior supporting ridge strongest, running from posterior side of chondrophore towards posterior hinge plate. Posterior primary teeth consist of one rather strong tooth in right valve, opposed by two teeth in left valve. Anterior primary teeth consist of a distinct and an obtuse tooth in the right valve, opposed by what seems a thickened dorsal margin in left valve. Pallial line entire and indistinct. Adductor muscle scars distinct and oblongly ovate. Inner ventral margin crenulated by radial shell structure.

Table 16. Rumptunucula vincentiana: measurements and number of teeth.

specimen	length	height	section	e.s.l.	i.d.l.	secondary teeth ant.	secondary teeth post.
holotype	2.32	1.88	0.62	0.38	1.32	7	2 and 3
MacDonnell Bay	2.45	1.95	0.68		± 1.14	9	3
MacDonnell Bay	2.05	1.59	0.50	± 0.40	± 1.14	7	3

MEASUREMENTS: See table 16.

RANGE: Eastern South Australia (fig. 72).

DISCUSSION: The original description and figure of *Pronucula vincentiana* are poor and inaccurate. Cotton and Godfrey (1938) wrongly claimed the presence of concentric ribs, the extension of the radial ribs on anterior and posterior valve ends, a perpendicular chondrophore and in general a hinge configuration as in *Nucula decorosa* (Hedley).

Cotton and Godfrey (loc. cit.) give Gulf St. Vincent as type locality. The box holding the type had this locality written on its lid by Cotton, but inside there is a Verco label reading "*Pronucula cancellata* n. sp. 15-20 fms. St. Francis Is". In my account of *Nucula mayi* (Iredale) in the present paper I already explained that Verco had labelled two samples in the South Australian Museum collection as "*Pronucula cancellata* Verco" but that this species was eventually published by Cotton (1930) under the same name. Cotton in his description mentioned St. Francis Island — and also the depth of 15(-20) fathoms — as one of the localities of his *Pronucula cancellata,* but the sample of this species from St. Francis Island has not been found since. I am convinced that Verco would never have confused such different shells as *Nucula mayi* (Iredale), i.e. the valid name for *Pronucula cancellata* Cotton, and *Rumptunucula vincentiana.* Thus Verco would never have identified material of the latter species as conspecific with his "*cancellata*". A more plausible explanation for the label with that name in the box of the *vincentiana* type is that Cotton, when preparing the section on the Nuculidae for The Molluscs of South Australia (Cotton and Godfrey, 1938), confused or mixed two labels while comparing the type of *vincentiana* with samples of *Nucula mayi.* The St. Francis Island label could then belong to the Gulf St. Vincent sample of *mayi* that has a Verco label without an identification (SAM D.15029), while the latter label could belong to the *vincentiana* type. Presumably, Cotton checked the collecting depth of the type of *vincentiana* after the exchange of labels, and copied the depth mentioned on the St. Francis Island label without noticing his error. If this reconstruction is correct, Gulf St. Vincent would be the correct type locality of *Rumptunucula vincentiana,* and the cited depth of 15-20 fathoms would be based on an error.

Other localities mentioned in the original description of *Pronucula vincentiana* are "off Cape Borda, 55 fathoms" and "north-west of Cape Borda, 62 fathoms". The samples providing these data apparently served Cotton when describing *Pronucula vincentiana,* and could therefore be referred to as paratypes (Mayr, 1969: 371). I have studied both samples, which had been put together in one bigger tube (fortunately each still with its own label) with a Cotton label covering both samples "*Pronucula vincentiana* Cotton and Godfrey". Both lots consisted of shells of *Nucula mayi* (Iredale), however. The label with Cotton's identification has been left with one sample, SAM D.15024, while the other sample has been separated as SAM D.15027. Apart from the type specimen I have seen only two other specimens of *Rumptunucula vincentiana,* both loose right valves. These came from MacDonnell Bay, South Australia, and were identified and listed by Cotton and Godfrey (1938) as *Pronucula decorosa* Hedley. These MacDonnell Bay specimens were the first of *vincentiana* that I studied, hence the drawings of the whole valve (figs. 45-47) are from one of these specimens and not from the holotype which I saw and found to be conspecific much later. In the right valve of the holotype part of the ventral margin and of the dorsal margin just behind the umbo are lacking.

Some indication of the conchological variability within *Rumptunucula vincentiana* is shown in figures 46 and 48. The form of the chondrophore is more rectangular and the supporting ridges are in a different position in the type (fig. 48) than in the MacDonnell Bay specimen (fig. 46). The posterior hinge plate is narrower in the type, and the primary

teeth are more prominent (though this may be due to a greater degree of wear in the MacDonnell Bay specimen).

SPECIMENS EXAMINED: South Australia: 1 from Gulf St. Vincent (holotype, SAM D. 13151); 2/2 from MacDonnell Bay (1/2: SAM D. 11306; 1/2: RMNH 55109).

Key to adult specimens of recent Australian Nuculidae except Ennucula Iredale, 1931

1. Hinge plate not interrupted beneath the umbo (chondrophore forming part of the hinge plate and at about the same level) 2

   Hinge plate interrupted beneath the umbo (chondrophore detached from and sunken beneath the hinge plate) ..... *Rumptunucula vincentiana*

2. Inner ventral margin of valves distinctly denticulated or crenulated 3

   Inner ventral margin of valves smooth 11

3. Chondrophore distinctly oblique and projecting beyond hinge plate; resilifer longer than broad 4

   Chondrophore either hardly or not projecting beyond hinge plate (if somewhat projecting then almost vertical); resilifer short, not longer than broad 5

4. Posterior margin straight, running either from a distinct posterodorsal angulation situtated halfway of the posterior secondary teeth row, or from directly beneath the umbo; posteroventral angulation distinct; chondrophore scarcely diverging from anterior part of hinge plate ..... *Nucula beachportensis*

   Posterior margin rounded or only partly straight; posterodorsal angulation usually broad and if more or less sharp, at or beneath the level of the last posterior secondary tooth (counting from the chondrophore); posteroventral angulation usually not distinct; chondrophore diverging from both anterior and posterior hinge plate sections ..... *Nucula pusilla*

5. Valves either smooth and then always without primary teeth, or with relatively strong concentric ribs and/or weak or deciduous radial riblets 6

   Valves either smooth and then always with primary teeth, or with equally valid concentric and radial riblets, or with relatively strong radial ribs and concentric striae 8

6. Valves without sculpture ..... *Nucula praetenta*

   Valves at least partly sculptured 7

7. Usually prominent concentric ribs (5-9) on anteroventral area of valves; no radial sculpture ..... *Nucula saltator*

   Usually prominent concentric ribs beyond interdissoconch; fine radial riblets in interstices ..... *Nucula torresi*

8. Valves with sculpture of about equally valid, rather narrow concentric and radial riblets 9

   Valves smooth, or with sculpture of relatively strong, rather wide radial ribs and weak concentric striae (or merely pronounced growth lines) 10

9. Radial riblets not on anterior and posterior valve areas; interdissoconch smooth except for some delicate growth lines ..... *Nucula mayi*

   Radial riblets covering whole valve beyond interdissoconch; interdissoconch with very delicate radial striae, especially on anterior, posterior and ventral areas, and with fine growth lines ..... *Nucula revei*

10. Chondrophore scarcely projecting beyond hinge plate, producing only a very slight curve on the ventral hinge plate margin; distinct primary teeth at either side of chondrophore; valve smooth or radially ribbed ..... *Nucula covra*

    Chondrophore projecting beyond hinge plate, being substantially longer than the width of the adjacent hinge plate parts; no primary teeth visible; valve with radial ribs ..... *Nucula decorosa*

11. Valve either with concentric ribs on dissoconch, or with delicate radial striae on (parts of) interdissoconch and dissoconch; teeth never tending towards lamellar form 12

    Valve smooth; anterior teeth tending to become lamelliform ..... *Nucula dilecta*

12. Dissoconch concentrically ribbed 13
    Dissoconch without concentric ribs ..... *Nucula brongersmai*

13. About 20 concentric ribs per mm of height ..... *Nucula australiensis*
    About 40 concentric ribs per mm of height ..... *Nucula papuensis*

GENERAL DISCUSSION

In the section on taxonomy I have referred to the zoogeographical regions proposed by Hedley (1904) for the marine Australian fauna. These regions, with some later emendations summarized by Iredale (1939:220), have been introduced on the distribution maps (figs 69-74). I have drawn the border between Flindersian and Peronian/Maugean according to the position of the vanished Bassian isthmus as figured by Hedley *(loc. cit.)*, from Wilsons Promontory in Victoria via the islands of the Furneaux Group to Cape Portland in north-east Tasmania. South of Tasmania it is thought to continue approximately in line with the South Tasmanian Ridge.

No attempt has been made to sketch a general outline of the zoogeography of the species of Nuculidae dealt with in this paper. Uneven collecting efforts made thus far would undoubtedly produce a biased concept. Moreover, it is felt that little justification exists for treating the species involved as a more or less natural group or unity. Such a group should at least comprise all Recent Australian Nuculidae. Apart from the new species which no doubt will be discovered, the known larger species of Australian Nuculidae strongly need a modern revision. For the present it seems wisest to leave the question of a general zoogeography to later workers. In the meantime the available data do allow some observations.

Most of the species (or species groups) that do occur in more than one zoogeographical region show a morphological variation which can be related to the zoogeographical compartimentation of their distribution areas. In general, *Nucula pusilla* Angas shells are typical in the Peronian region, possibly more frequently thinner in the Maugean, thicker and in part concentrically ribbed in the Flindersian and Dampierian, and in addition in northern populations in the latter region have a posterior marginal incurvation. *N. beachportensis* Verco seems more frequently typical in the

Peronian, Maugean and Flindersian, while the shells from the Dampierian region would more often represent the triangular, sculptured variety. *N. torresi* Smith occurs in Peronian, Solanderian and Dampierian regions, developing a different style of sculpture in the latter region. Typical shells of *N. covra* Bergmans, from the Flindersian region, are more solid, less angular and less sculptured than Peronian shells of this species. A variation at species level occurs in the closely related species of the *australiensis* group: *N. australiensis* (Thiele) in the Dampierian and Flindersian, N. *papuensis* Bergmans in the Solanderian, and *N. brongersmai* Bergmans in the Peronian, Maugean and eastern Flindersian regions. *N. dilecta* Smith, with the subspecies *dilecta* Smith in the Peronian, *flindersi* (Cotton) in the Flindersian, and *diaphana* Prashad in the Dampierian region, shows an early stage of such a differentiation.

The patterns of distribution of the involved Nuculidae suggest that the most important zoogeographical borders are those between the Solanderian (and probably Banksian) and Peronian regions, and between the Dampierian and Flindersian regions. It is also suggested that for the Nuculidae the latter border lies more to the north than it should according to Hedley (1904). In short, there seems to exist an obviously northern Australian nuculid fauna and likewise a southern one.

The marine mollusc fauna of the northern half of Australia is poorly represented in collections. This region roughly includes the shores and waters of the Kimberley region, Arnhem Land, the Gulf of Carpentaria and the mainland coast of Queensland. The supposed zoogeographical border here is that between the western Dampierian and the eastern Banksian/Solanderian. It is noteworthy that a form of *Nucula torresi* Smith, a species described from the Solanderian, has been collected in the centre of the Dampierian region, while the same may be true for *N. saltator* (Iredale). Moreover, I have seen specimens of the Solanderian *Ennucula privigna* Iredale, 1939, from south of Sweers Island in the southern Gulf of Carpentaria (AM C. 78223 and C. 75249). It would appear from these examples that the border between the two northern regions is of less concern to species which, like the Nuculidae, inhabit sandy or muddy substrates than to those which are exclusively inhabiting coral reef environments. The Great Barrier Reef Nuculidae (Iredale, 1939) may therefore be expected to occur at either side of the border between the mentioned regions. I equally doubt the value, for the Nuculidae, of the border between the Solanderian and Banksian regions.

The Nuculidae of the southern half of Australia are comparatively well known. It is evident that not too much value should be attached to the border between the Peronian and Maugean regions. Of the five species of smaller Nuculidae found in both regions only *Nucula pusilla* Angas shows a very slight morphological distinction. A more important border is that between Peronian and Flindersian though a large transition area can be recognized. Shallow water species from the Peronian region and from the Great Australian Bight probably meet a barrier of some importance in the Bass Strait area, with its distinctly lower temperatures (Hydrographic Office, U.S. Navy, 1954). Deep water species may meet a barrier in the shallow Bassian isthmus.

In general we may expect a more restricted distribution for shallow water species than for those living at greater depths, where environmental conditions remain practically constant over much larger areas. A good example of the latter category is *Nucula dilecta* Smith. This species is known from depths of 250 to 959 m, and its subspecies are not only found in the Dampierian, Flindersian and Peronian regions, but also in Indonesian waters and probably — via the South Tasmanian Ridge and the Southwest Auckland Rise? — in New Zealand.

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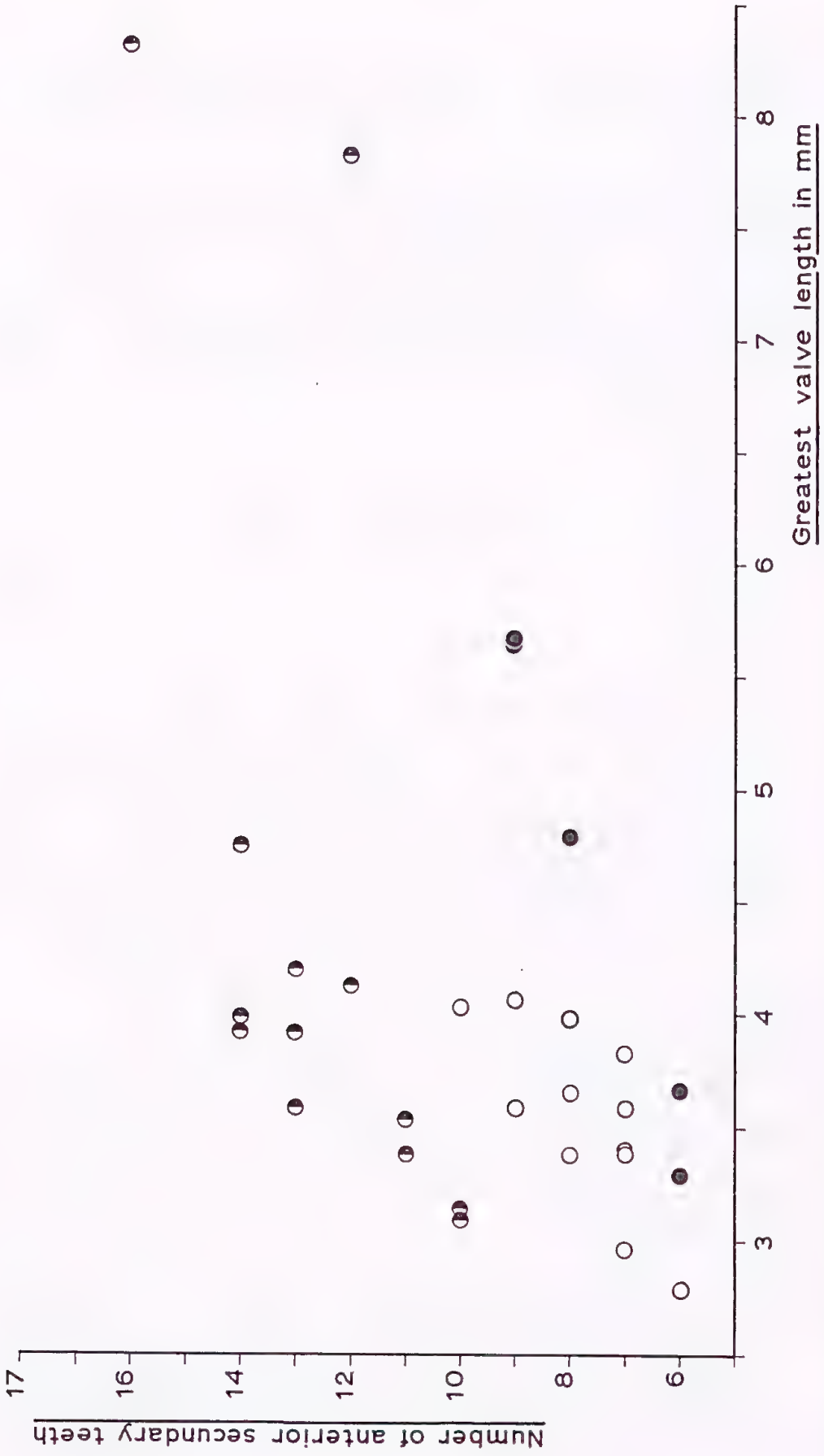
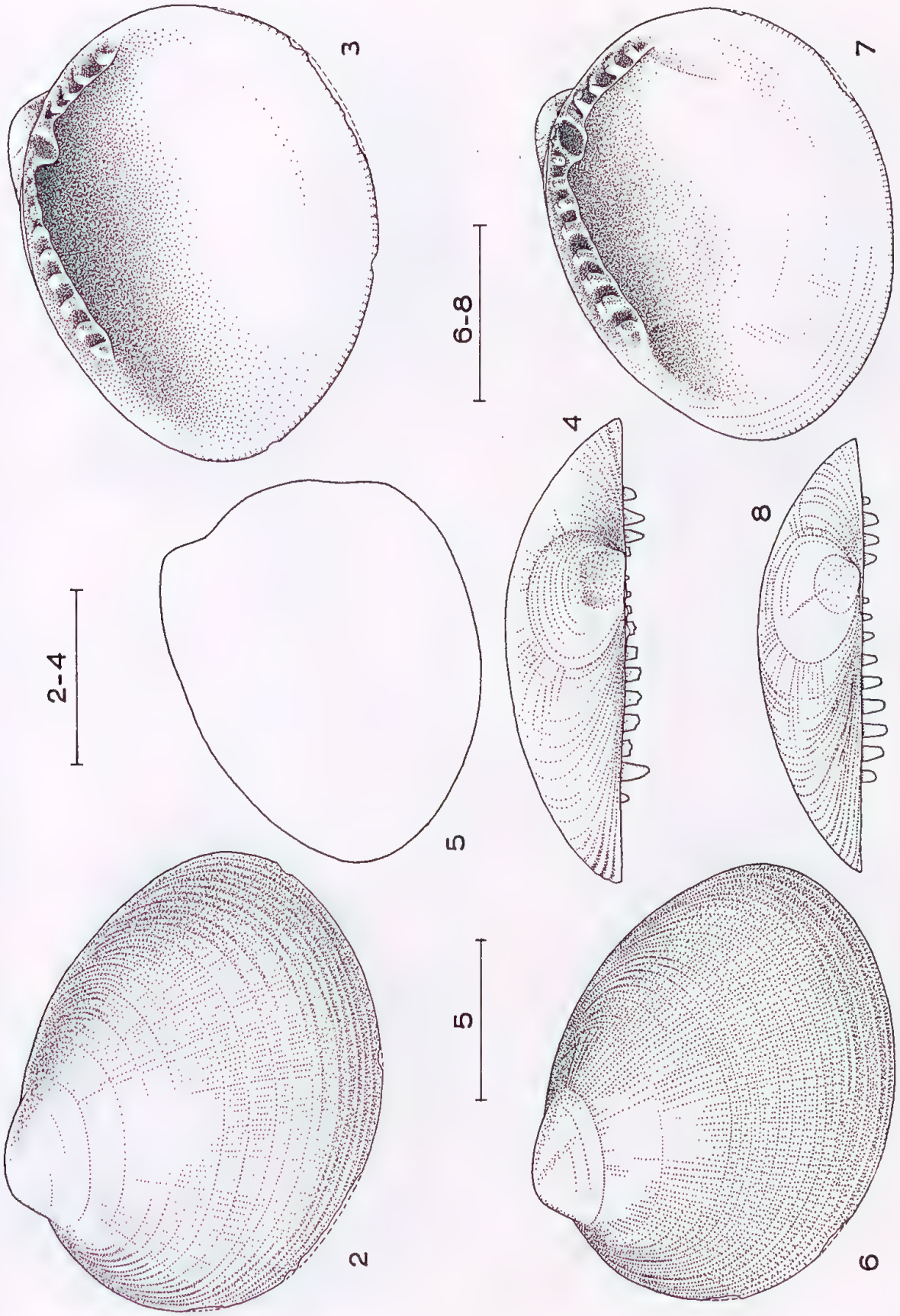
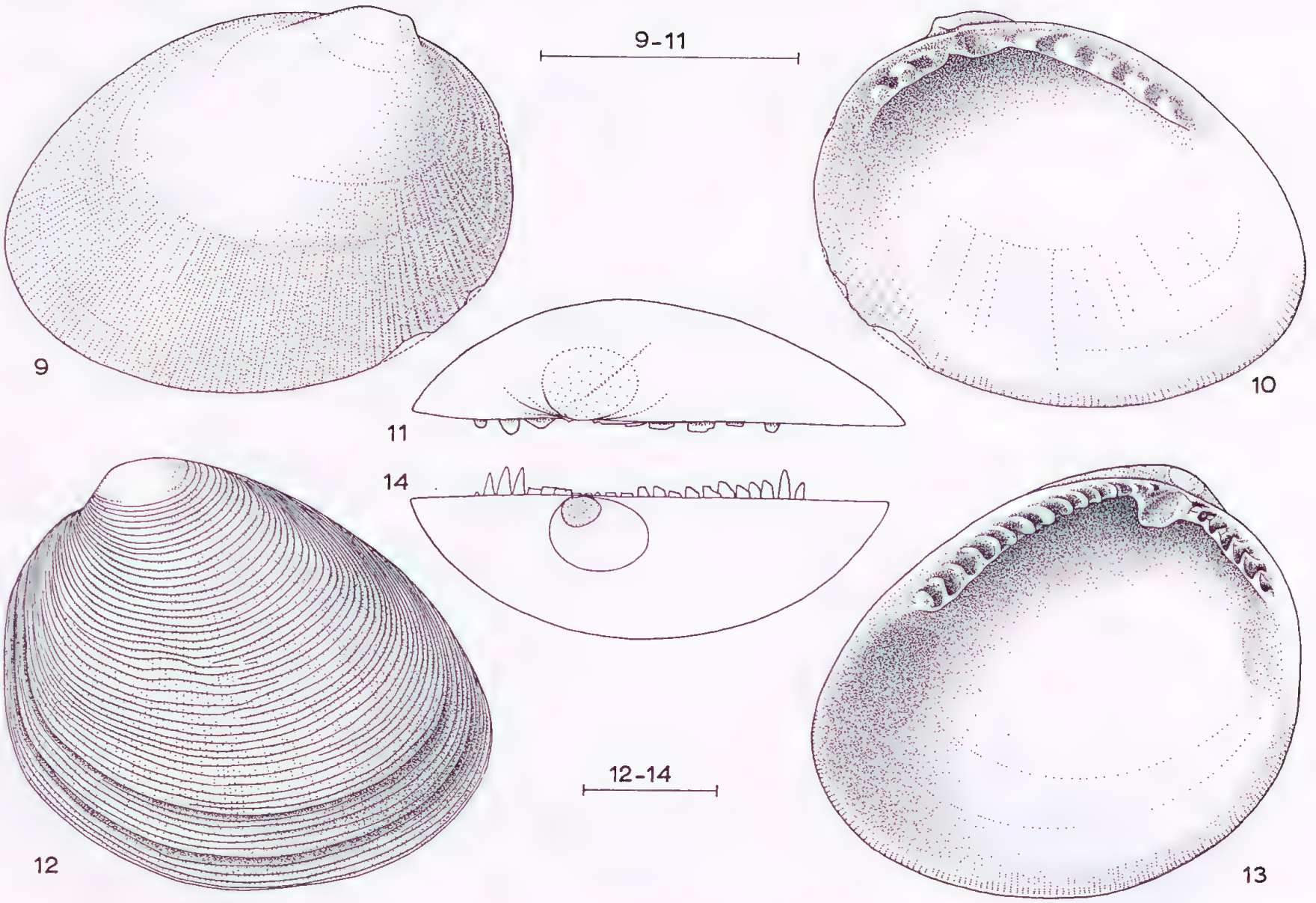


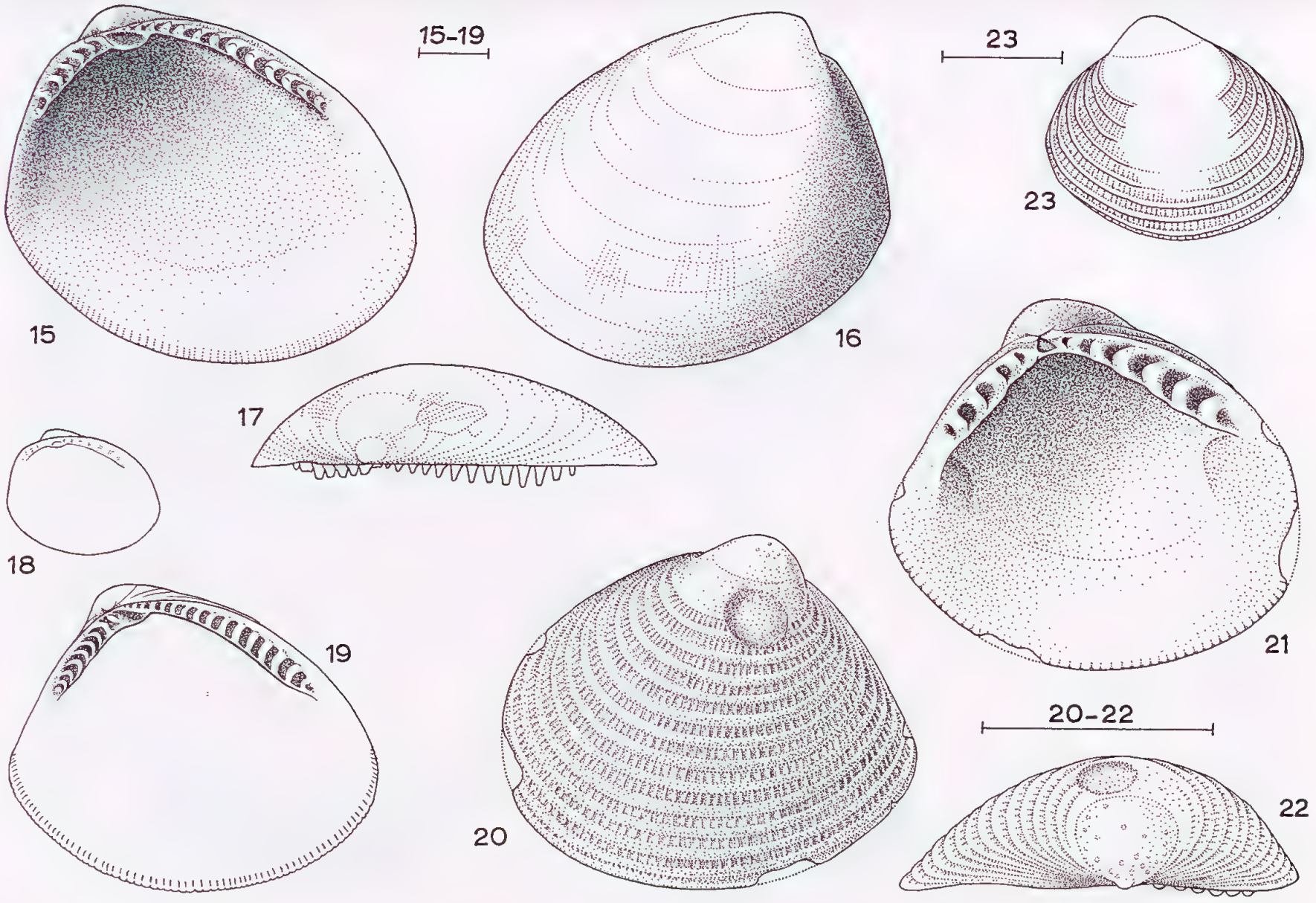
Fig. 1. *Nucula dilecta* Smith: the number of anterior secondary teeth as a function of the greatest valve length in mm. Black dots: *Nucula dilecta dilecta* Smith; open circles: *Nucula dilecta flindersi* Cotton; black-and-white dots: *Nucula dilecta diaphana* Prashad.



Figs 2-4. Lectotype of *Nucula pusilla* Angas, Port Jackson, New South Wales (BMNH 1877.5.12.61), scale 1 mm. Fig. 5. *Nucula pusilla* Angas, Shark Bay, Western Australia (WAM809-71), scale 1 mm. Figs 6-8. *Nucula pusilla* Angas, Brighton, South Australia (lectotype of *Nucula micans* Angas: MMNH 1879.1.31.8/2), scale 1 mm.

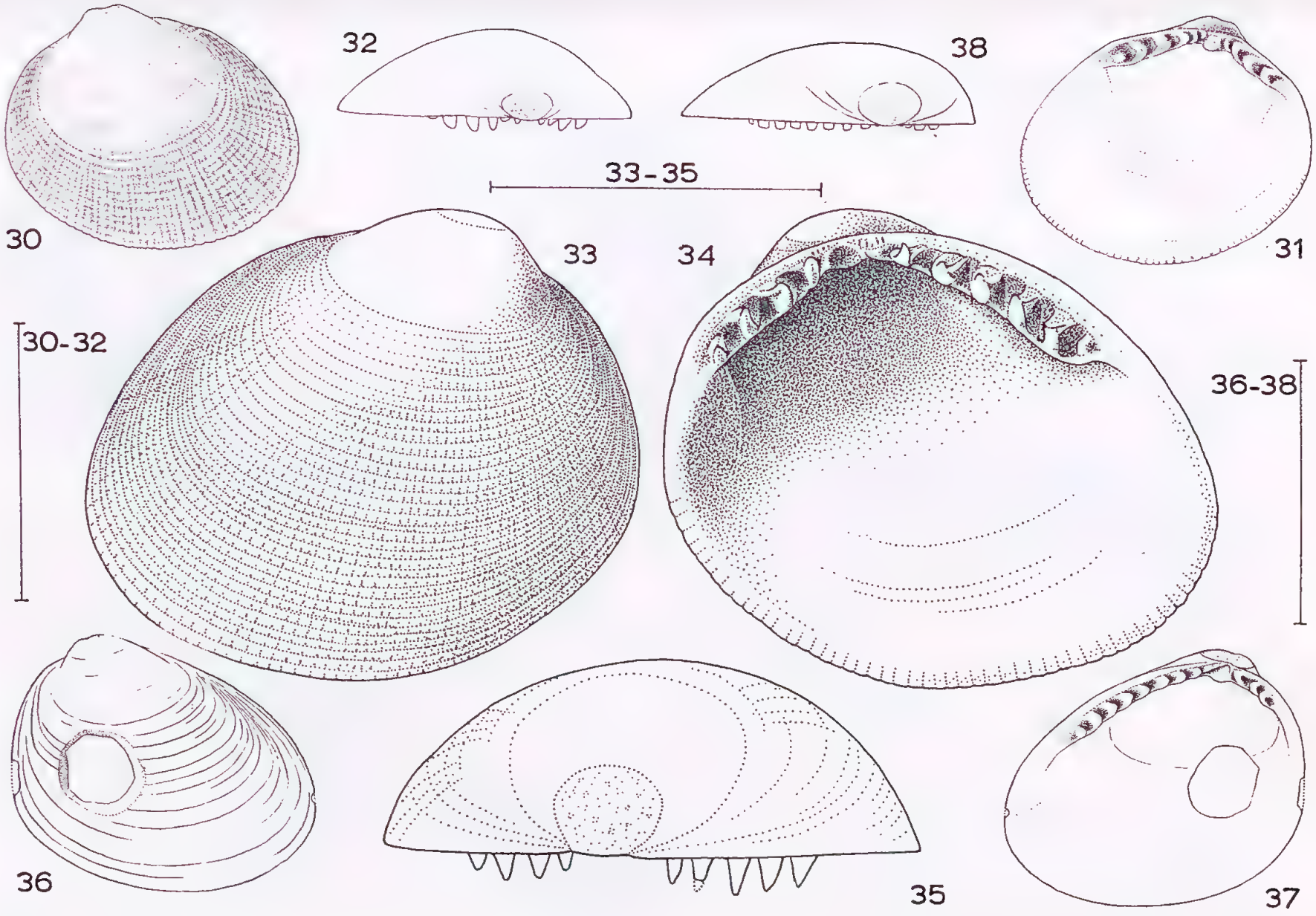


Figs 9-11. *Nucula pusilla* Angas, Blackmans Bay. Tasmania (lectotype of *Nucula hedleyi* Pritchard and Gatliff; TAS E18e/7359), scale 1 mm. Figs 12-14. *Nucula pusilla* Angas, Gulf St. Vincent, South Australia (holotype of *Pronucula concentrica* Cotton; SAM D.10115), scale 1 mm.

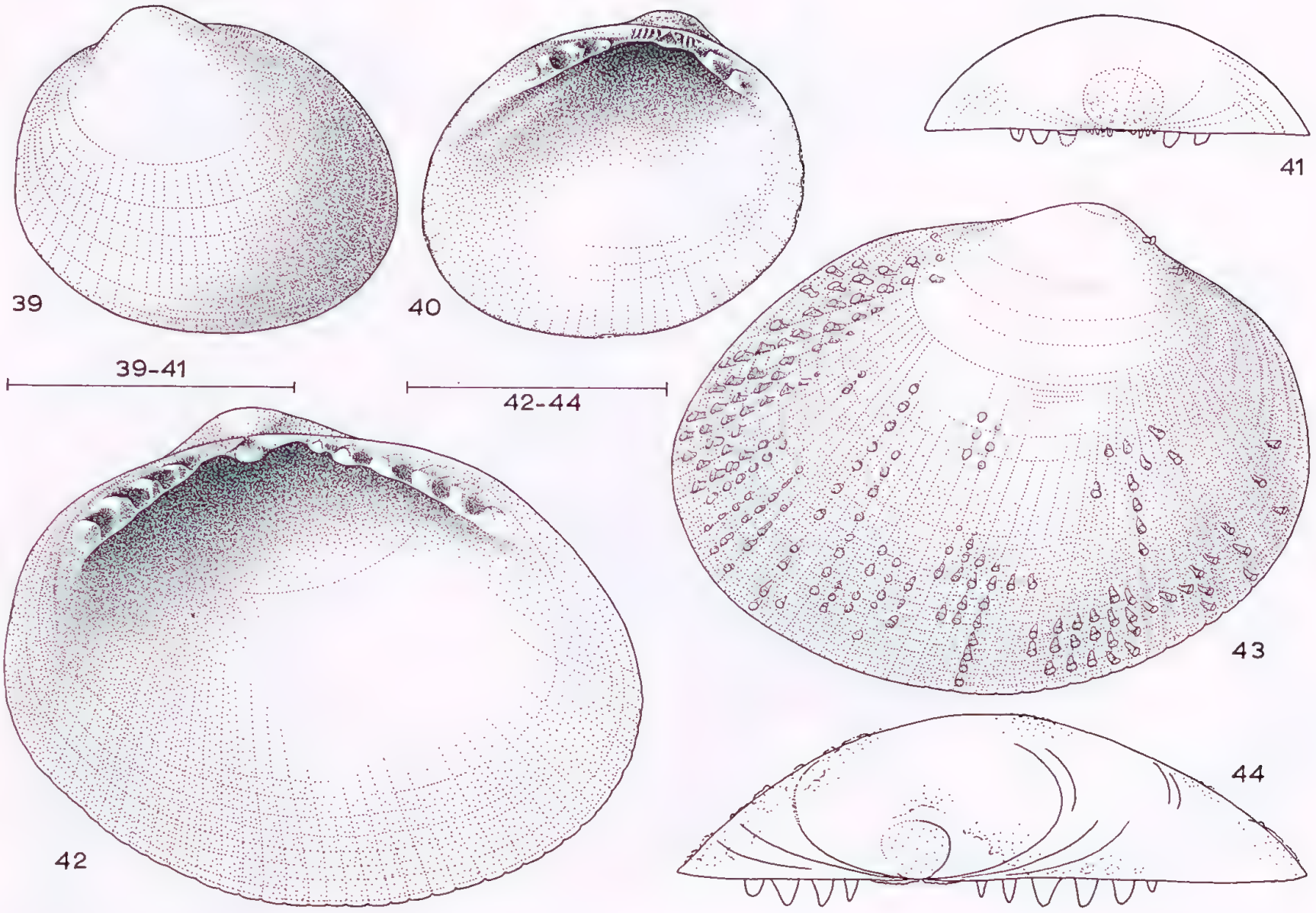


Figs 15-17. Holotype of *Nucula beachportensis* Verco, off Beachport, South Australia (SAM D.11310). Fig. 18. *Nucula beachportensis* Verco, 30 miles south of Cape Everard, Victoria (AM C.83128. Fig. 19. *Nucula beachportensis* Verco, south of Rowley Shoals, off Western Australia (WAM 800-71); scale 1 mm. Figs 20-22. *Nucula torresi* Smith, Port Stephens, New South Wales (holotype of *Pronucula voorwindei* Bergmans; AM C.67030), scale 1mm. Fig. 23. *Nucula torresi* Smith, approximately 135 miles north-west of Roebuck Bay, Western Australia (AM C.88702), scale 1mm.

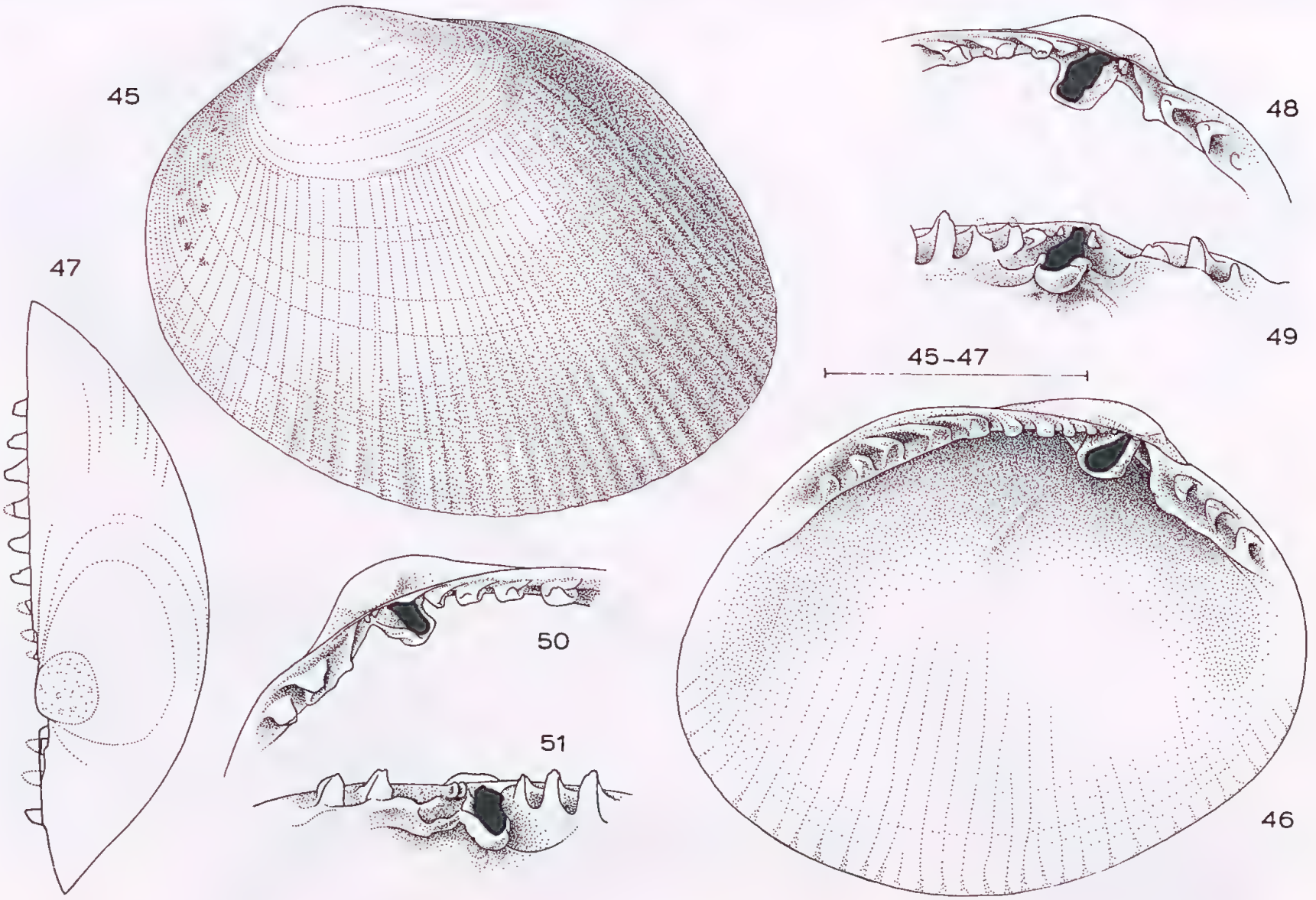
Figs 24-26. Lectotype of *Nucula praetenta* Iredale, off Sydney, New South Wales (BMNH 89.2.13.12-13/1), scale 1 mm. Figs 27-29. Lectotype of *Nucula saltator* (Iredale), Low Isle, Queensland (AM C.60256), scale 1 mm.



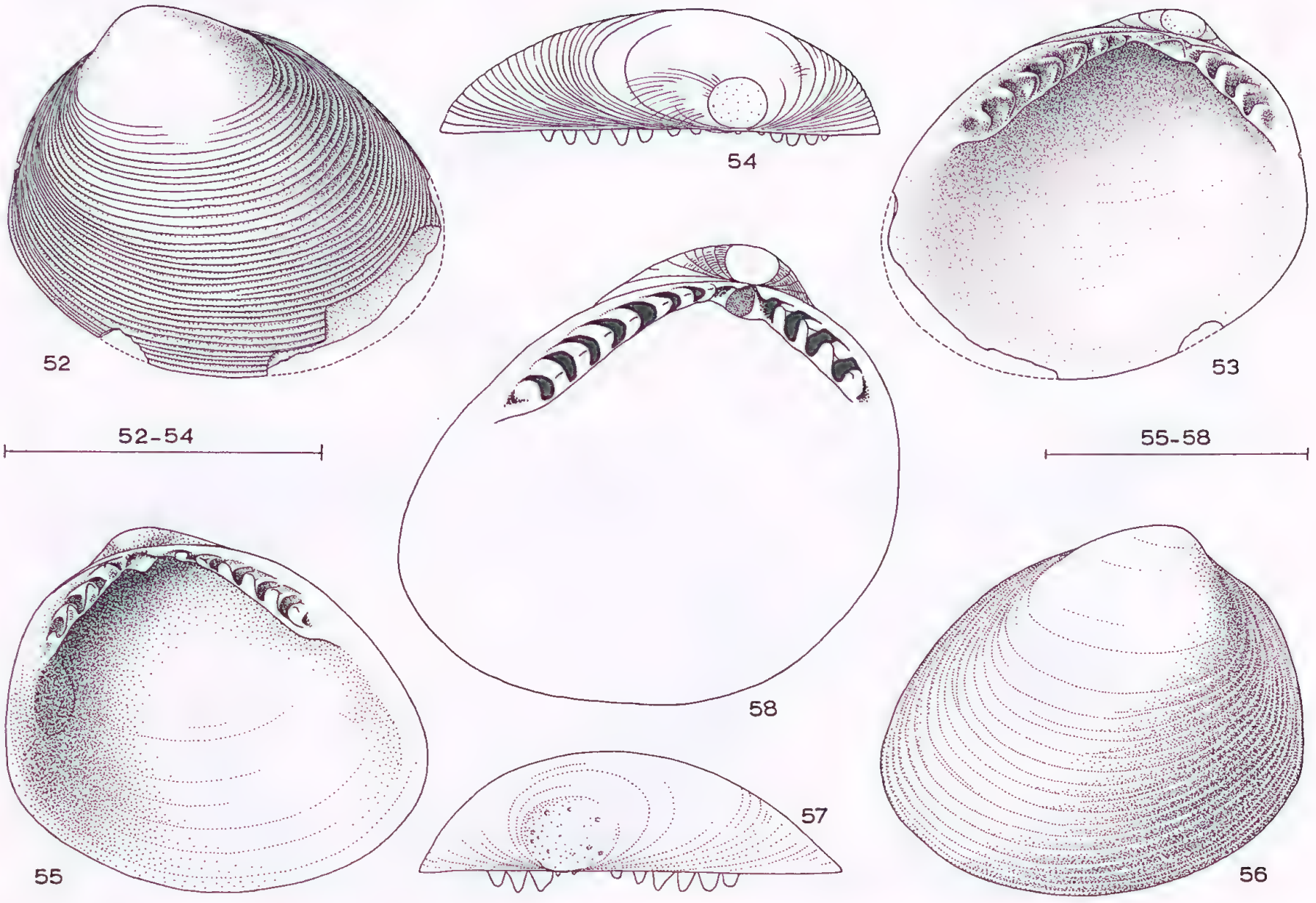
Figs 30-32. Holotype of *Nucula revei,* new species, Narrabeen, New South Wales (RMNH 52697), scale 1 mm. Figs 33-35. *Nucula mayi* (Iredale), Pilot Station, D'Entrecasteaux Channel, or Union Bay, Tasmania (SAM D. 15021), scale 1 mm. Figs 36-38. *Nucula* species, Narrabeen, New South Wales *(Pronucula micans,* Bergmans, (not (Angas, 1878)) 1968, *J. malac, Soc. Aust.* 11: 78, pl. 12, figs 6a-c), scale 1 mm.



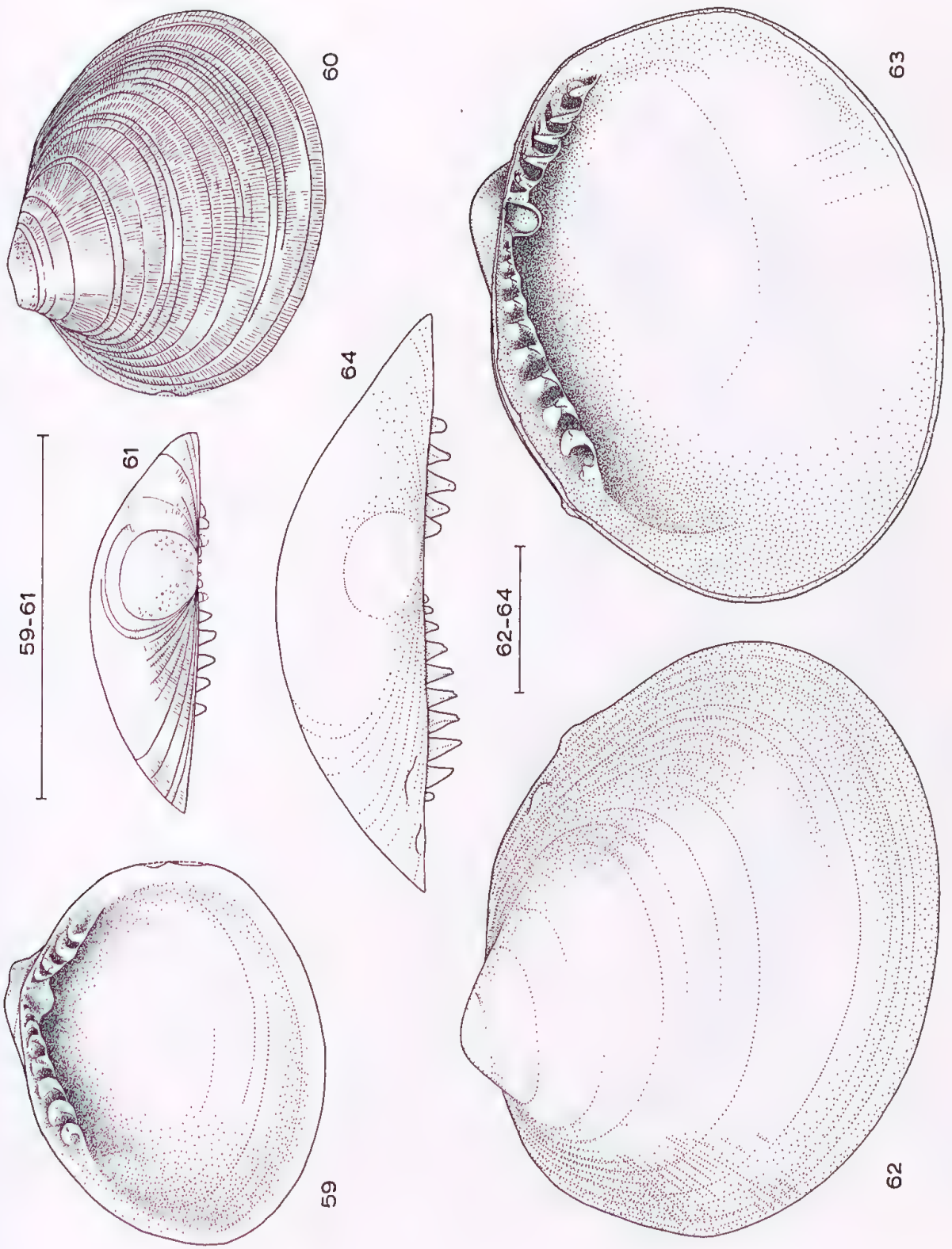
Figs 39-41. Holotype of *Nucula covra*, new species, 40 miles south of Cape Wiles, South Australia (AM C.88707), scale 1 mm. Figs 42-44. Paratype of Nucula decorosa (Hedley), off Port Kembla, New South Wales (AM C.12309), scale 1 mm.



Figs 45-51. *Rumptunucula vincentiana* (Cotton & Godfrey), MacDonnell Bay, South Australia (SAM D.11306), scale 1 mm. Figs 48-51. Holotype of *Rumptunucula vincentiana* (Cotton & Godfrey), Gulf St. Vincent or St. Francis Island, South Australia (SAM D.13151); fig. 48: hinge of right valve; fig. 49: ventral view of right valve hinge; fig. 50: hinge of left valve; fig. 51: ventral view of left valve hinge; scale figs 48-51 somewhat larger than that of figs 45-47. Remnants of ligament shown in black.



Figs 52-54. Holotype *Nucula papuensis*, new species, Albany Passge, Queensland (AM C.100961), scale 1 mm. Figs 55-57. *Nucula australiensis* (Thiele), Skippy Rock, Careening Bay, Garden Island, Western Australia (WAM 1147-75), scale 1 mm. Fig. 58. *Nucula australiensis* (Thiele), Gulf St. Vincent, South Australia (SAM D.15090), scale 1 mm.



Figs 59-61. Holotype of *Nucula brongersmai*, new species, Primrose Sands, Tasmania (TAS E5373), scale 1 mm. Figs 62-64. Holotype of *Nucula dilecta flindersi* (Cotton), 120 miles west of Eucla, Western Australia (SAM D.10116), scale 1 mm.

Fig. 65. Holotype of *Nucula dilecta diaphana* Prashad, between Sumba and Flores, Indonesia (ZMA), hinge of right valve. Fig. 66. Lectotype of *Nucula dilecta dilecta* Smith, off Sydney, New South Wales (BMNH 89.2.13.22-30/1). Fig. 67. *Nucula dilecta diaphana* Prashad, south of Rowley Shoals, off Western Australia (WAM 801-71). Fig. 68. Paratype of *Nucula dilecta flindersi* (Cotton), 120 miles west of Eucla, Western Australia (SAM D.1587). Scales applies to all figures.

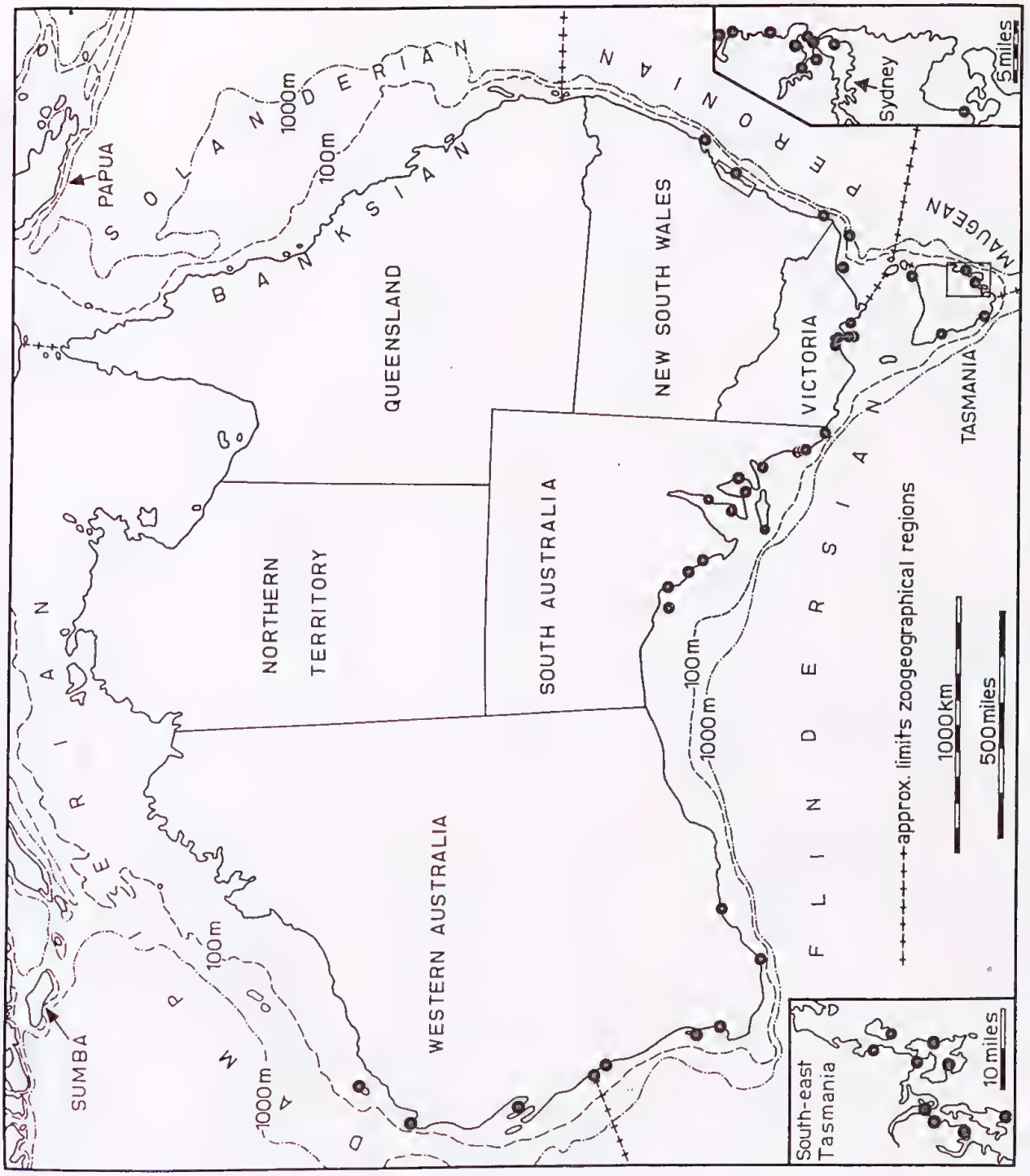


Fig. 69. Collecting localities of *Nucula pusilla* Angas (black dots).

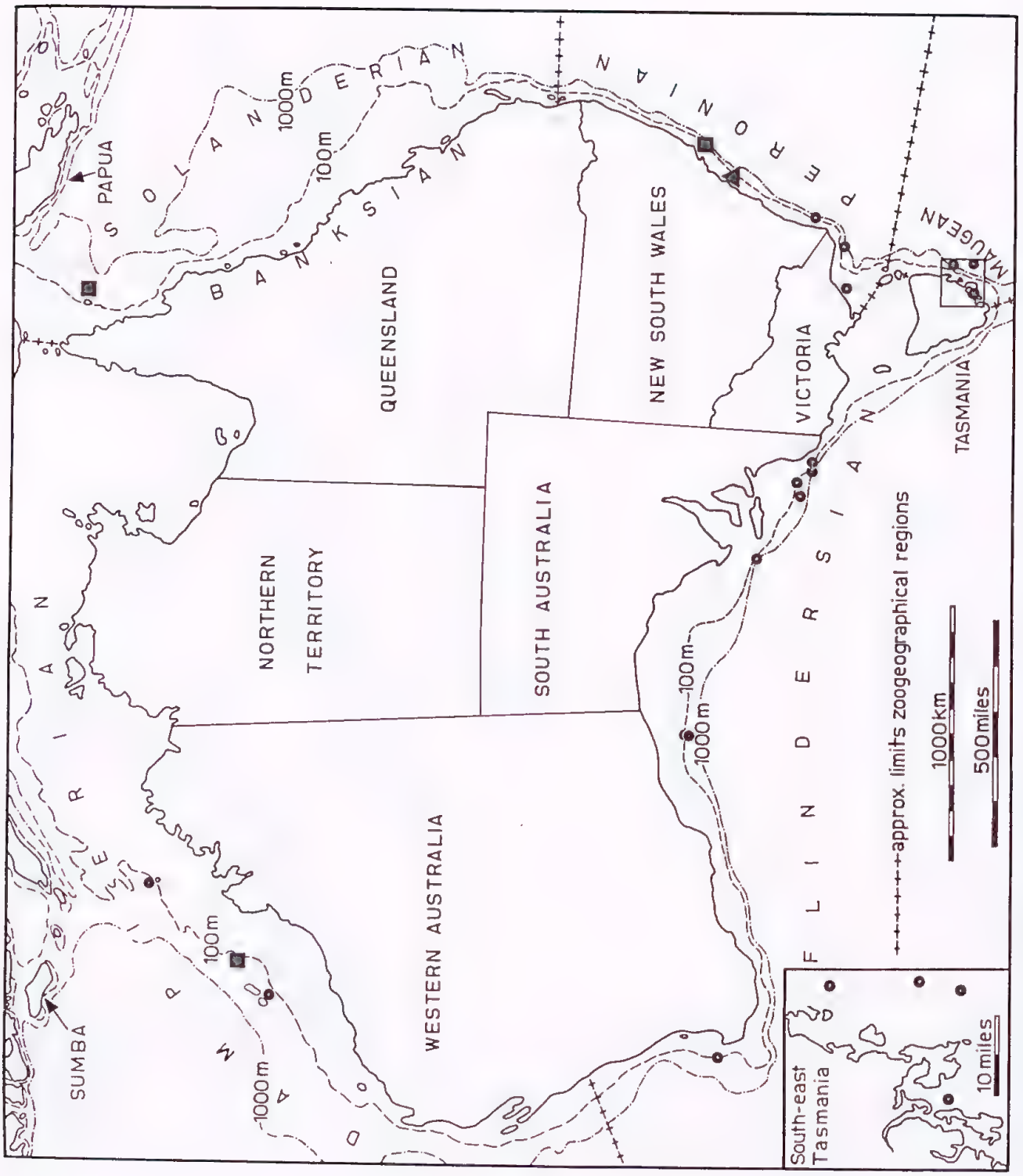


Fig. 70. Collecting localities of *Nucula beachportensis* Verco (black dots), *Nucula torresi* Smith (black squares), and *Nucula praetenta* (Iredale) (black triangle).

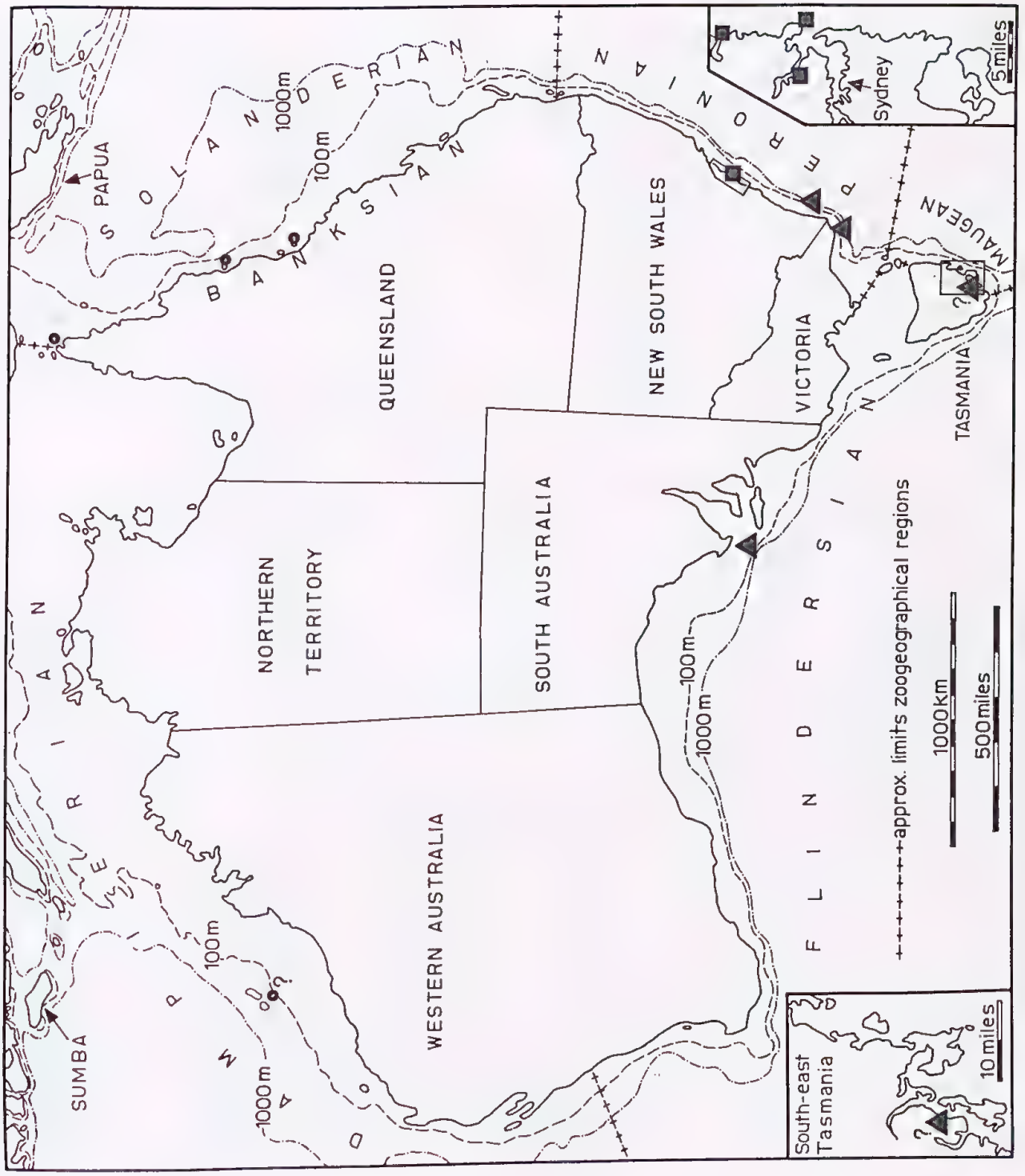


Fig. 71. Collecting localities of *Nucula saltator* (Iredale) (black dots), *Nucula covra* Bergmans (black triangles) and *Nucula revei* Bergmans (black squares).

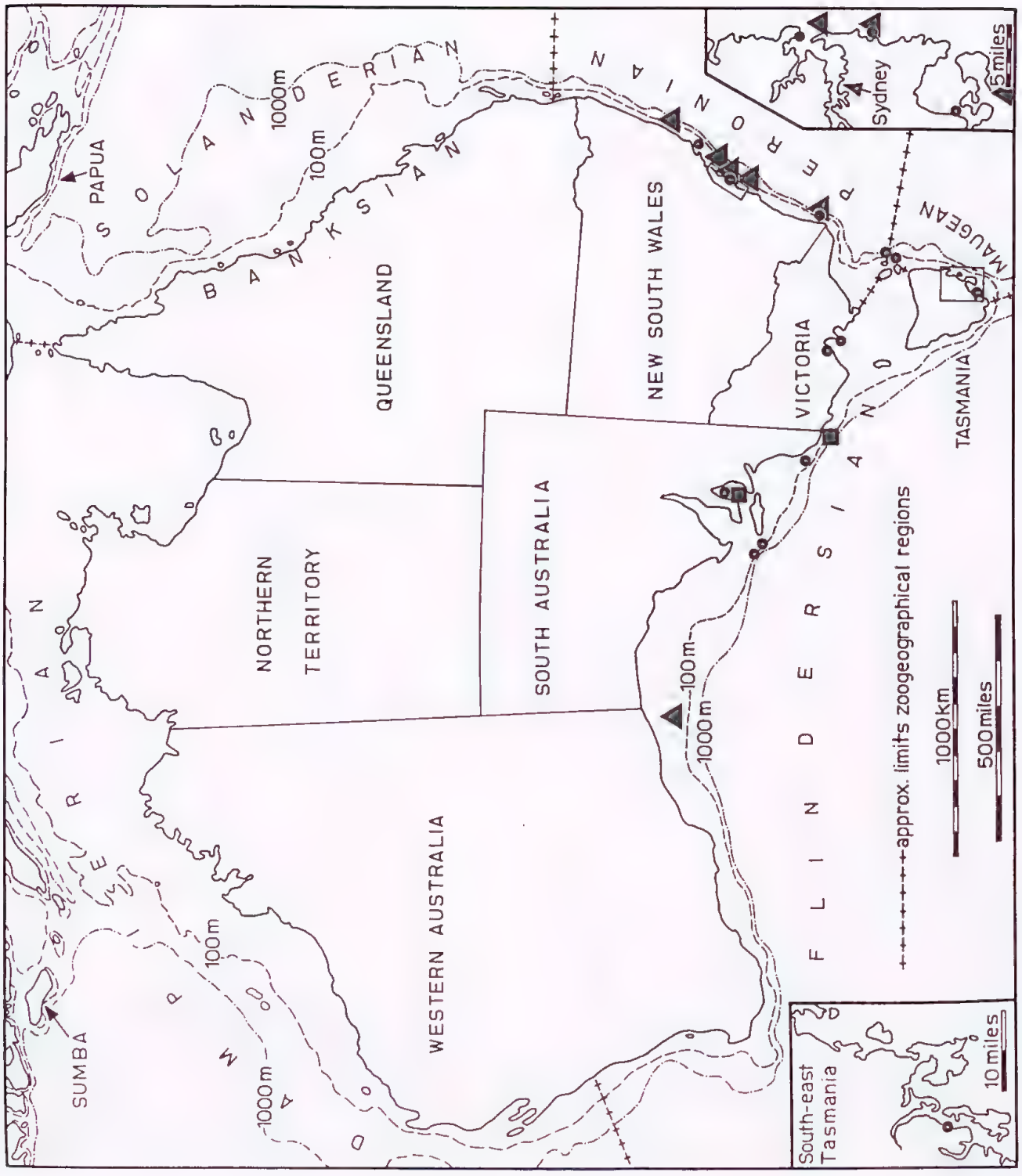


Fig. 72. Collecting localities of *Nucula mayi* (Iredale) (black dots), *Nucula decorosa* (Hedley) (black triangles), and *Rumptunucula vincentiana* (Cotton & Godfrey) (black squares).

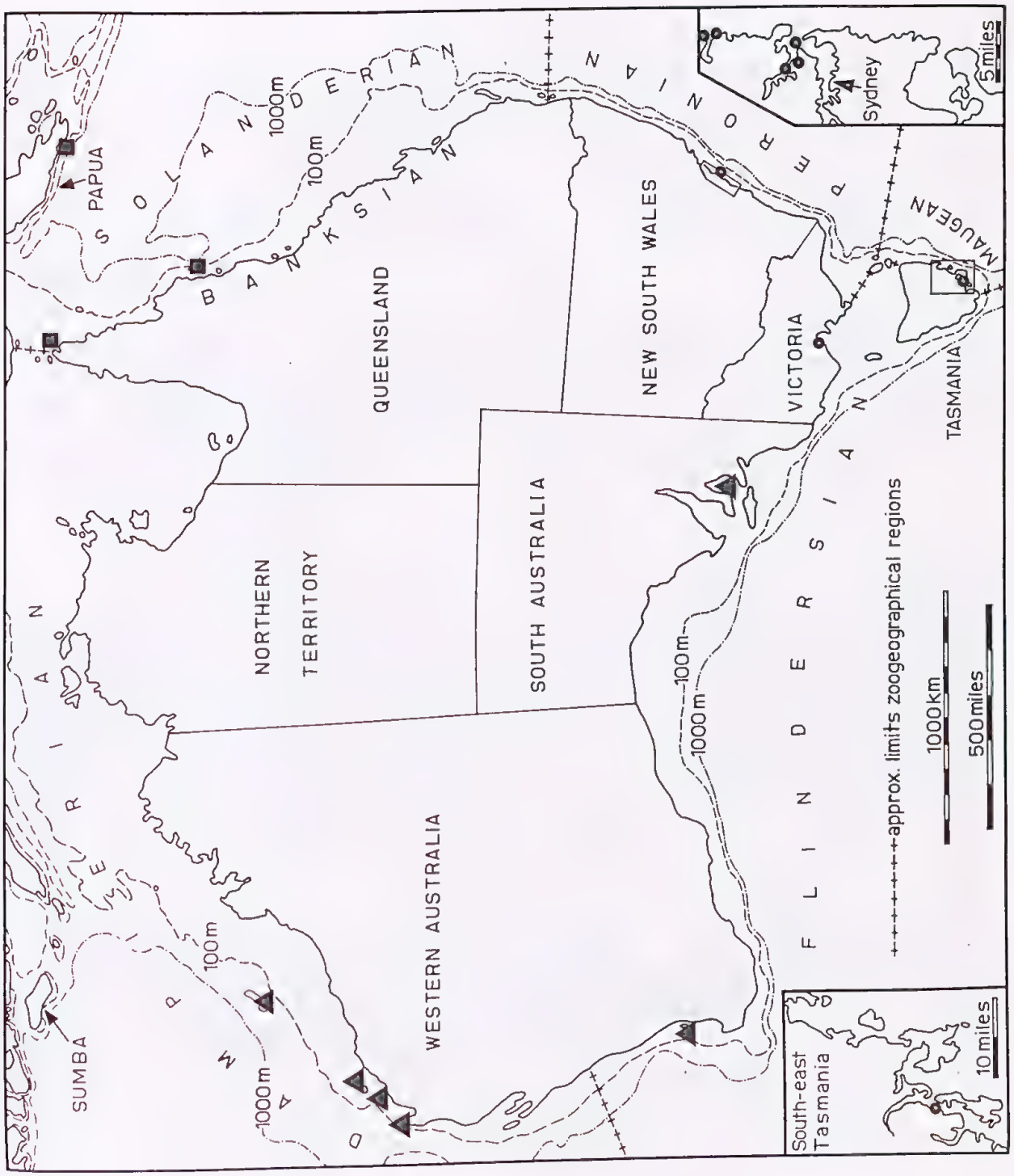


Fig. 73. Collecting localities of *Nucula australiensis* (Thiele) (black triangles), *Nucula brongersmai* Bergmans (black dots), and *Nucula papuensis* Bergmans (black squares).

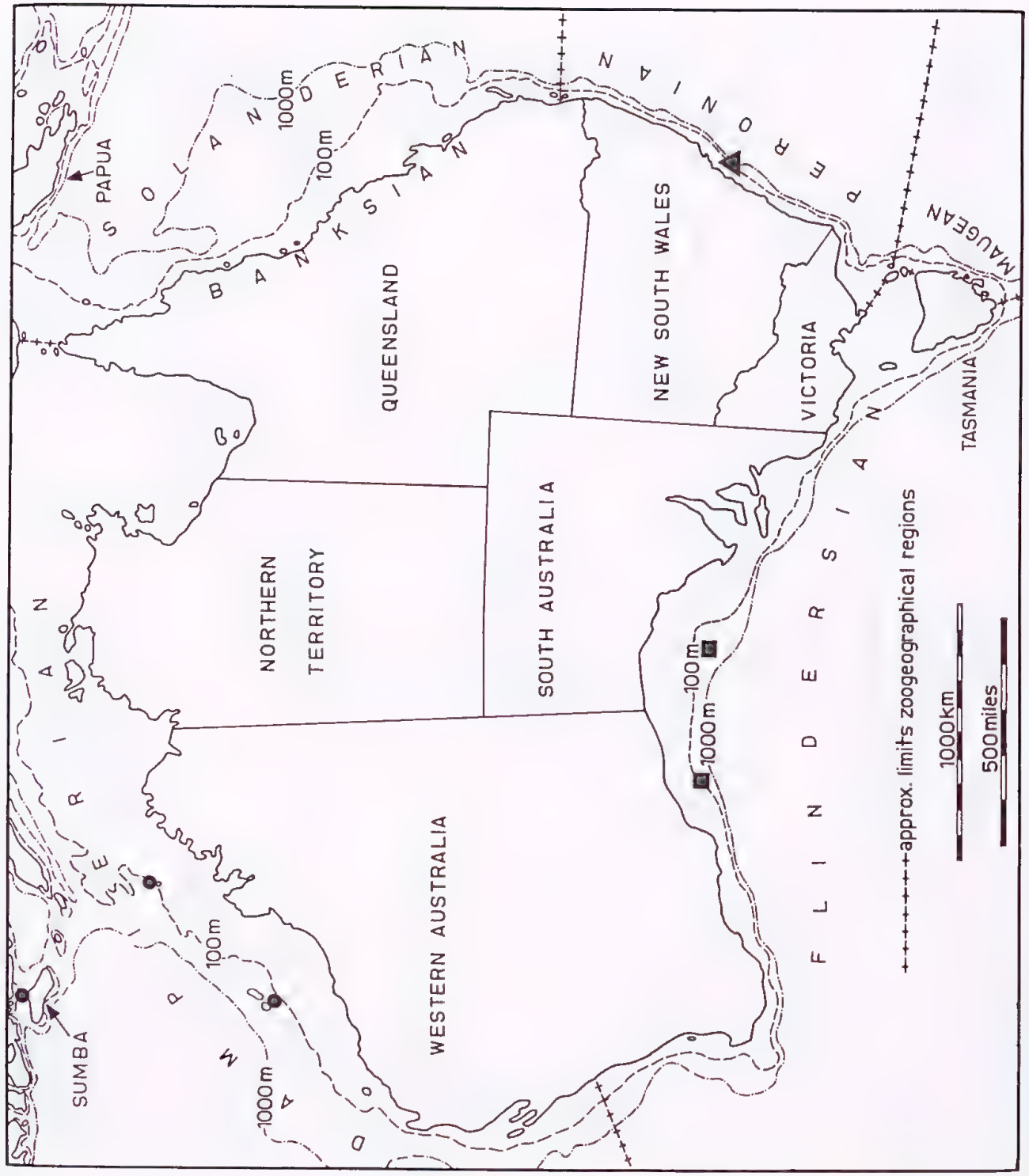


Fig. 74. Collecting localities of *Nucula dilecta dilecta* Smith (black triangle), *Nucula dilecta diaphana* Prashad (black dots), and Nucula dilecta flindersi (Cotton) (black squares).

UNDERWATER OBSERVATIONS ON SEA SNAKE BEHAVIOUR

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SUMMARY

Sea snakes forage on the bottom but often bring prey to the surface to swallow. Surface activity not exclusively associated with feeding or breathing, sometimes occurs, especially at night. The skin is usually shed entire; it is loosened by rubbing against coral, curling and knotting or expanding the body. Courtship consists of the male swimming above the female and slightly behind her and then later pressing his body against hers while she rests on the sea bottom. Other topics are briefly discussed.

INTRODUCTION

The book, *The Biology of Sea Snakes* (ed. W.A. Dunson, 1975), has summarized the literature on sea snakes and presented much new information; it has also served to indicate some of the gaps in current knowledge about this group of reptiles. One of the most conspicuous areas in which almost no data are available is the behaviour of the animals in their natural habitat. Few herpetologists are divers, and vice versa; only recently have undersea observations been made and information is still mostly fragmentary and opportunistic. The data we have collectively accumulated contribute to little-known areas of sea snake biology and we present them here. Underwater observations were made either by snorkeling or diving with SCUBA; timing was done with a Nivada-Grenchen underwater chronograph.

FEEDING

Except for the pelagic, surface-feeding *Pelamis platurus,* and perhaps *Lapemis hardwickii* which is reported to take prey at various levels of the water column (McCosker 1975), the food of most sea snakes would indicate that they capture prey on the bottom. Many, for example, eat burrowing eels, crevice-inhabiting fish, or species that are restricted to the bottom (McCosker 1975).

Records of The Australian Museum, 1978, **Vol. 31 No. 18,** 000-000, Figures 1-12

Observation confirms the bottom-feeding habit for many species. Most snakes observed underwater were either (1) inactive and resting on the bottom or coiled among corals or rocks, or (2) engaged in what we interpret as foraging on the bottom. Most of our observations have been on coral reefs so our results apply primarily to that habitat. Foraging behaviour in *Aipysurus laevis, Aipysurus duboisii* and *Astrotia stokesii* has been observed many times and is practically identical. The snakes differ primarily in the places they forage (Heatwole 1975a, McCosker 1975) rather than in their manner of foraging.

These snakes swim leisurely among the coral, nearly continuously investigating crevices in the coral or algae by protruding their snouts into them (Fig.1). In some cases, the snake will enter crevices with most or all of the body. Often a snake systematically searches a complete clump of coral before moving on to the next one. When an area of sand or other flat substrate is reached the snake swims rather rapidly and in a generally straight line to the next area of coral. The directness of such swimming contrasts markedly with the sinuous path followed while foraging. Individual snakes have been followed and observed to forage continuously for over half an hour. However, we have actually witnessed the capture of a fish by a sea snake in the wild only once.

The above species usually ignore free-swimming fish even when they swim close to the snake's head, and it is probable that they are unable to catch fish unless they corner them in crevices. Excerpts from field notes illustrate this point:

Cato Lagoon, Coral Sea, 2 May 1968, 1645 hrs, notes by H.H. "An *A. duboisii* in 2-15 cm of water on reef flat; slowly swimming or crawling depending on depth; poked head into small crevices in dead coral rubble; ignored small fish (2-4 cm long) that came within about 5 cm of head; on some occasions small fish left crevices when the snake investigated them and darted away; snake seemed to pursue them for about 15 cm but then returned to foraging."

Swain Reefs, Coral Sea, 29 June 1971, 1415 hrs, H.H. "An *A. laevis* foraging in 10 m water; . . . it foraged over a semicircle of about 50 m during 21 min.; a number of small fish of various species came within 2-5 cm of its snout; it didn't react overtly to them; approached by a large fish, seemingly by chance; the fish swam away; touched a sea turtle while foraging; no overt reaction by either animal."

Saumarez Reef, Coral Sea, 1 July 1971, daytime, H.H. "An *A. duboisii* loosely coiled in a cavity in a piece of dead coral in 4 m of water; it did not change position or location for 1 hr 20 min (when observations were terminated); during that time four species of small fish swam in and out of the cavity, even among the coils of the snake; no overt response by the snake."

Ashmore Reef, 3 Jan 1973, S.A.M. "In an area of coral with water 1-2 m deep, watched an *Emydocephalus annulatus* for about 15 min as it swam just above the bottom investigating crevices and holes in the coral and sand. During this time it surfaced once for breath and immediately submerged. It passed within a few cm of an *Aipysurus foliosquama* lying on the bottom. It was more or less oblivious to contact with various reef fish and they ignored it." Also at the same place H.H. saw several small fish enter a loose clump of coral in which a resting *A. dubosii* was coiled; the snake did not overtly respond to the fish. See also notes of 30 June 1971, 1324 hrs, quoted below.

Swallowing sometimes occurs at the surface, even if fish are caught on the bottom. On 1 July 1971 at Saumarez Reef, Coral Sea, an *A. duboisii* was first observed (H.H.) leaving the bottom in about 10 m of water. It was heading for the surface with a still struggling (presumably just caught) fish about 3 cm long in its mouth. In an attempt to observe swallowing, the investigator approached closely and the snake released the fish

Fig. 1. *Disteira major* subduing and swallowing an eel in the sea. Photograph by Ron and Valerie Taylor.

and returned to the bottom. The fish floated at the surface for a few seconds, flapping feebly, and then recovered and swam away; it was not identified. Similarly, an *Astrotia stokesii* was observed on the surface in about 10 m of water at Ashmore Reef, Timor Sea. It had a fish, which appeard to be a scorpaenid (a bottom dwelling group) transversly in its mouth; the snake's neck was curved and it was holding the fish against its body, apparently attempting to turn the fish around to swallow it headfirst. It released the fish when an attempt was made to catch the snake; the fish swam away.

A nearly complete feeding sequence was observed near Magnetic Island, Australia (notes by V.T.). "Ron thought he could see a sea snake doing something strange on the surface. It was a large pale sea snake about 2 m long and it was fighting with an eel about 1½ m long. The snake was obviously winning althought the eel had drawn blood in many places. Ron filmed from the surface in 35 mm movie as the two animals writhed around on the surface . . . The sea snake finally got the eel by the tail and began to swallow him. We all got into our diving gear but . . . by the time we entered the water only the head of the eel stuck out the snake's mouth. When the snake saw us coming he made a last giant swallow and the head disappeared. The snake lay upsidedown in a sort of stupor. The eel could be seen slowly moving down inside the snake's body which was stretched to bursting . When the head of the eel was about 15 cm down his throat the snake came to life and snatched a breath of air . . . It took the snake about 6 minutes to swallow the eel. The water was about 20 m deep." The sea snake was subsequently identified as *Disterira major* from the photographs (see Fig. 1). These observations are important as they indicate that some sea snakes can actively subdue large prey, even rivalling land snakes in terms of the size of prey taken.

Swallowing at the surface is not obligatory, however. *A. laevis* swallows its prey on the bottom. At Swain Reefs in November 1976, five different individuals of this species were fed fish at night. The technique was to place the recently killed fish in the path of a foraging snake. When it bumped the fish with its snout it protruded its tongue against it several times and then rapidly bit the fish 1-3 times. A small fish would be then immediately swallowed. When dealing with larger fish, the snake would work its head completely around the periphery of the fish, finally returning to the original site. This procedure probably enables the snake to assess the fish's size and aids in determining whether it is small enough to swallow. If the fish were very large the snake would leave it and swim away, but if it were of moderate size, the snake would find the head and swallow the fish head-first. The swallowing process was very similar to that in a terrestrial snake. Prey wider than the diameter of the snake's head or body could be swallowed. Usually the snake surfaced and breathed immediately after the meal. Several swallowing sequences have been recorded on film by Ben Cropp Productions. On 8th January 1973, at Scotts Reef, Timor Sea, in about 4 m of water, a large *A. laevis* was observed in a clump of coral with its tail and part of the posterior body protruding. It was grasped by the body and pulled from the coral, at which time it was noted to have a scorpaenid fish in its mouth. Even after capture the snake continued trying to swallow the fish but eventually it dropped it; the fish swam away.

The fact that in all these cases, captured fish were still alive and capable of swimming away when released suggests that the venom of sea snakes may not not be as lethal to fish as is generally believed.

It is not necessary for the prey to be alive to be taken by *A. laevis*. On two occasions in Cato Lagoon, Coral Sea, large individuals were observed to approach and attempt to eat the dead, but fresh, heads and offal of fish which had been thrown overboard. In one case, the snake bit into the head despite the fact it was much too large to be swallowed by the snake (also see feeding experiments mentioned above).

Other fish-eating species probably actively forage much in the manner described above. Some are known to investigate holes in the bottom (Fig. 2).

Some species eat only fish eggs (Voris 1966, McCosker 1975) and would perhaps be expected to use somewhat different foraging patterns.

Emydocephalus annulatus and *Hydrophis gracilis*[1] are two such species. Although inhabiting coral reefs, they do not investigate crevices in coral. Rather they poke their snouts into the sand. The former species has a sharp spine on the snout which may aid in penetrating the sand (Fig. 3) although since the spine is more pronounced in males it may have other functions. *H. gracilis* has been observed with its head down in the sand feeding on fish eggs:

Saumarez Reef, Coral Sea, 3 July 1971, 1400 hrs, H.H. "An *H. gracilis* in 5 m of water on bare sand; head and part of neck down a hole just large enough to receive it; posterior part of body floating upward and waving back and forth in the current; caught after 35 min." (See also photo in Macleish 1972).

E. annulatus ingests large quantities of sand while eating eggs buried in sand. Of 15 specimens of this species from the Coral Sea that were opened and the gut examined, 14 (93%) had the stomach and /or intestine packed with sand (Heatwole 1975a). Such a large amount of ballast undoubtedly influences the buoyancy of this species. A number of sea snakes swallow fish with heavy spines. As fish are swallowed, their spines may sometimes penetrate the body of the snake. M. A. Smith (1926) states, "According to Annandale, when fishes with strong spines are devoured, the spines can be eliminated from the snake's body by passing out through the wall of the alimentary canal and the body-wall to the exterior. He states that he has frequently found sea snakes with the fish spines actually protruding from the integument without apparently causing any inflammation or inconvenience." We have observed this in three specimens of *Hydrophis ornatus* collected in the Visayan Sea. In two cases a fish spine had penetrated the body wall at about the level of the stomach, in a third it had penetrated the tissues of the head (Fig. 4). One of these snakes died the day following capture; however, death could not be confidently attributed to the injury. *H. ornatus* in Philippine waters seems to feed almost exclusively on catfish of the genus *Plotosus* that are equipped with strong, serrate venomous spines, and such injuries must be relatively frequent in the snake population. However, in at least 13 additional instances snakes had fed on these catfish without sustaining any obvious injuries.

DAILY ACTIVITY

Heatwole and Seymour (1975a, b, 1976) indicated a diel rhythm in metabolic rate of sea snakes (6 species) such that values were higher during the day than at night; this suggests a diurnal activity pattern. Certainly, in all the species of sea snakes we have observed underwater, some individuals foraged by day; others, however, were observed to be inactive, either lying on the bottom or coiled in crevices (Fig. 5). We have observed *A. laevis* underwater probably more than any other species. It is sometimes active by day as described above but is also active at night. More than 7 hours were spent at night observing snakes at Swain Reefs in November 1976 (H.H.). Many were actively foraging and readily accepted fish when fed by hand. Others, however, were inactive, coiled motionless among the corals. The following excerpts from field notes illustrate these two activity categories:

1. This species was identified in the field as *Hydrophis gracilis*. A single live specimen was retained for postive identification; however, it died and disintegrated in transit and its identification must remain tentative until further specimens are obtained. These remarks apply wherever the name *H. gracilis* appears throughout the paper.

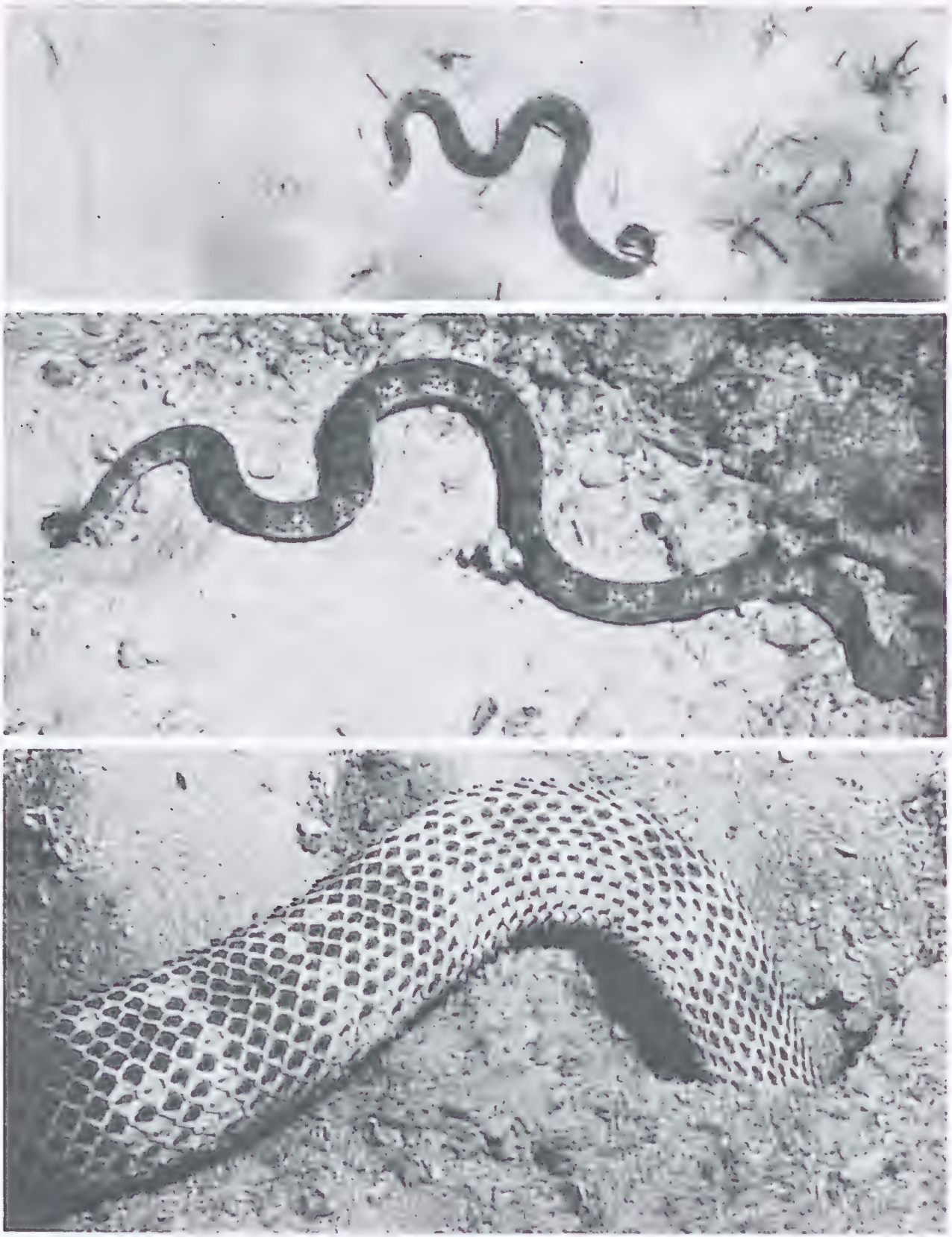

Fig. 2. Sea snakes foraging in holes in the bottom. Upper: *Aipysurus apraefrontalis*. Photograph by Sherman Minton. Centre and Lower: *Acalyptophis peronii*. Photographs by Ron and Valerie Taylor.

Fig. 3. Head of a male *Emydocephalus annulatus*. Note sharp spine on snout. Photograph by Ben Cropp.

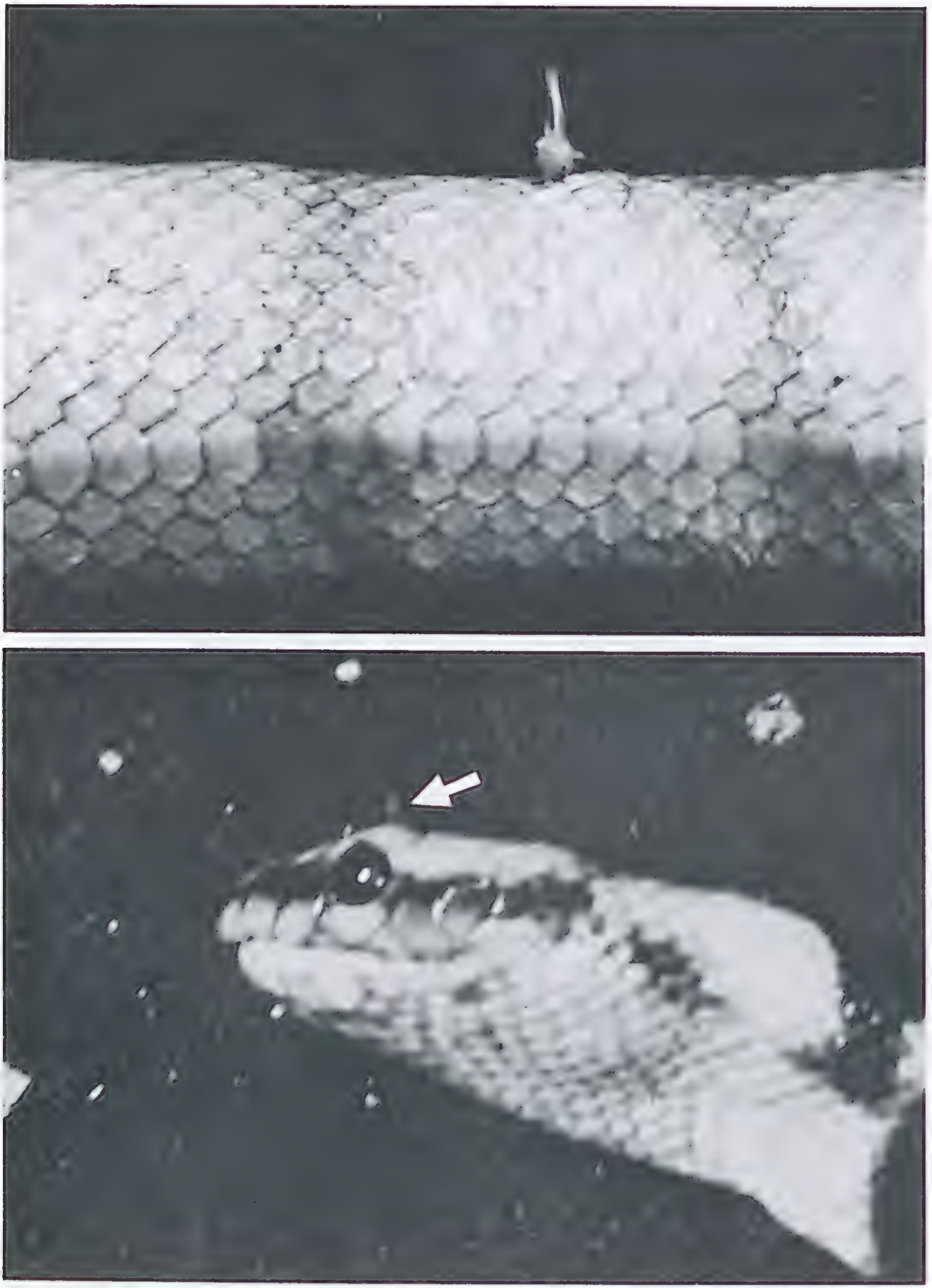

Fig. 4. Spines of a fish protruding through the body wall (upper) and through the head (lower, at point of arrow) of *Hydrophis ornatus*. Photographs by Sherman Minton.

Fig. 5. An inactive *Aipysurus duboisii* coiled on the bottom. Photograph by Ron and Valerie Taylor.

Active:

Swain Reefs, Coral Sea, 29 June 1971, 1455 hrs, H.H. "*A. laevis* found foraging around edge of large coral head in 10 m water. It poked snout under edge of coral where it abutted on sand; crossed sand-patch rapidly and repeated same process at next coral head; after 9 min came up for 1 breath, then came over to me; I nudged it gently with the snake tongs and it went to bottom and continued foraging for 10 min. 2 sec. more, then surfaced for 1 breath and dived again and continued foraging; observations discontinued 2 min later."

Swain Reefs, Coral Sea, 30 June 1971, 1324 hrs, H.H. "*A. laevis* found foraging on bottom; investigated all species and morphological types of corals including soft corals, shelf corals, brain corals, etc.; didn't forage on extensive patches of dead coral rubble or sand; crossed those rapidly, or turned back to live coral; all foraging was at base of coral except for investigation of one crevice 1 m up side of a coral head; surfaced for a breath after 16 min, then continued foraging 26 min more; ignored all free-swimming fish 2 cm to 15 cm long even when they came within several cm of the snake; once several swam out from under a coral head when the snake stuck its head under; the snake ignored them and they returned to the crevice as soon as it left; observations terminated." See also notes of 2 May 1968 and 29 June 1971 previously quoted.

Inactive:

Ashmore Reef, Timor Sea, Jan 1973, 1512 hrs, H.H. "An adult *A. duboisii* coiled motionless under a clump of staghorn coral in 2 m water; after 9 min 20 sec moved head out of coral and 30 sec later gradually rose toward surface and when free of coral went straight up; took one breath and then went straight to bottom, then along bottom for 3 m and entered a different clump of staghorn coral; became motionless; 32 min 40 sec later moved head out and then surfaced; it swam horizontally on surface for 3-4 m with head out (breathed?) then dived vertically, investigated an overhanging coral ledge for about 5 sec, then moved into a staghorn clump 4-5 m from its previous resting site; entered clump and became motionless." See also notes for 1 July 1971 quoted above.

Foraging and resting are often closely interspersed throughout the day as indicated by the following excerpts from field notes:

Cato Lagoon, Coral Sea, 2 May 1968, 1445 hrs, H.H. "*A. duboisii* under *Porites* coral in 1.5 m water; came up for one breath, then swam slowly, investigating crevices in coral; after 5 min 40 sec coiled up under dead staghorn coral; total distance travelled about 24 m; 16 min 43 sec later came up and breathed once, then swam slowly away into deeper water and was lost."

Table 1 summarizes all the data recorded of the activity of snakes at the time they were first sighted while making underwater observations. Even allowing for the fact that inactive snakes are more difficult to see than foraging ones, a high degree of diurnal activity is indicated.

The factors determining whether a given snake will be active or inactive are not known. Although nutritional state may be involved, it is not always the decisive factor as some foraging snakes have food in the stomach (one *A. duboisii* had a conspicuously large food bulge) and inactive ones may be post-absorptive; no quantitative assessment of such observations was made, however.

Table 1. Activity of sea snakes for which activity was recorded when first observed underwater. The category "other" includes swimming on surface, surfacing to breathe, and courting.

SPECIES	NO. OF SNAKES (% OF TOTAL)			
	FORAGING	INACTIVE	OTHER	TOTAL
Aipysurus laevis	28(74)	8(21)	2(5)	38
Aipysurus duboisii	10(46)	11(50)	1(5)	22
Aipysurus apraefrontalis	1	0	0	1
Aipysurus foliosquama	0	1	0	1
Aipysurus fuscus	1	0	0	1
Emydocephalus annulatus	19(63)	6(20)	5(17)	30
Astrotia stokesii	4	2	1	7
Hydrophis gracilis	1	2	0	3
Total	64(62)	30(29)	9(9)	103

Snakes secreted in crevices of coral are difficult to dislodge and their use of such places may be a protection against predation. On one occasion an attempt to pull an *Astrotia stokesii* from among coral resulted in the coral breaking off and coming with the snake. In some cases when snakes entered crevices in large coral heads, they retreated so deeply that they could not be seen, or reached by snake tongs, a distance of a metre or more.

Some species are frequently observed swimming on the surface at night, as well as by day. Diurnal surface activity seems to be more common when the surface of the sea is glassy smooth; no quantitative data are available however. At Ashmore Reef, many snakes were captured at night from the deck of the *Alpha Helix*. Most of the surface activity of *Hydrophis melanocephalus* occurred after dark. Of the 115 specimens of this species taken, nearly all were secured by nocturnal dip-netting from the ship. *Acalyptophis peronii* also usually surfaced at night but sometimes did so in the late afternoon. Diurnal captures of *Astrotia stokesii* on the surface were about as frequent as nocturnal ones. *A. laevis* was predominantly diurnal and occasionally swam at the surface in the daytime; a few were captured at the surface at night. *A. duboisii* was collected at night on one occasion. Although active by day, it was not often identified on the surface. No nocturnal observations at Ashmore Reef were made in the shallow water zone favoured by *Aipysurus fuscus, Aippsurus foliosquama, Aipysurus apraefrontalis,* and *Emydocephalus annulatus* and no specimens of these species were secured by nocturnal dip-netting. Diurnal observations indicated these species spend little time at the surface even by day.

Nocturnal surface activity of snakes could not be correlated with either time or meteorological conditions. Some nights many snakes appeared, other nights few or none. On the night of January 4-5, 1973, snakes appeared in great numbers between 2200 and 0200 hrs and about 40 were captured. On January 13, 1973, about the same number were captured between 0100 and dawn.

Sea snakes were also observed on the surface at night in the Visayan Sea (Philippines) during the *Alpha Helix* cruise in 1975. The largest single night's catch was 22 snakes taken September 10-11, the majority being *Laticauda laticaudata, L. colubrina,* and *Hydrophis cyanocinctus*. Two of the most common sea snakes of the area, *Laticauda semifasciata* and *Hydrophis ornatus,* were rarely observed from the *Alpha Helix* at night. Many were brought to the ship by local fishermen. However, precise collecting data were not available. Among the other relatively common species, *Hydrophis belcheri* appeared to

be predominantly nocturnal and *H. inornatus* almost exclusively diurnal. In comparison with species observed at Ashmore Reef, Philippine sea snakes remained on the surface for shorter periods and dived with much less provocation. This may reflect species differences or adaptation to a longer and more frequent contact with man.

The function(s) of prolonged surface activity by sea snakes, either diurnally or nocturnally, remains a mystery. Sea snakes seldom if ever, build up extensive oxygen debts when diving (Seymour and Webster 1975, Heatwole and Seymour 1975b, 1976) and hence a prolonged stay at the surface is not required for respiratory reasons. Thermoregulation remains a possibility as vertical thermal gradients occur in the water column; this would not explain the highly sporadic nature of the occurrence of nocturnal surface activity, however. It has been suggested that diurnal surface activity in sea snakes is thermoregulatory basking (Cowles 1962). However, snakes in water elevate their body temperature only slightly above water temperature by absorbing solar radiation (Dunson and Ehlert 1971, Graham *et al.* 1971, Graham 1974) and it is doubtful whether surface activity in sea snakes is really related to basking.

It would seem that diurnal surface activity may in fact be disadvantageous in areas where sea eagles are common as these birds prey on sea snakes (Heatwole 1975c).

To date, no explanation of surface activity in sea snakes (except for the surface-feeding *P. platurus)* is completely convincing and this is an aspect of sea snake biology which should be studied further.

LOCAL MOVEMENTS

At least some species of sea snakes undergo seasonal inshore-offshore movements (Shuntov 1971). However, their local movements when in a given locality are poorly known.

The only information currently available consists of observations by two of us (R.T., V.T.) on the reefs just north of Lizard Island, Queensland. There was an old steel drum submerged on the bottom in about 25 m of water which served as a shelter for a number of marine organisms and was consequently visited frequently over a 3-week period for filming purposes. Three snakes were associated with this drum throughout this period, 2 *Aipysurus laevis* and 1 *Astrotia stokesii*. They were usually curled up next to it or foraging nearby. If they were not there when the divers arrived they usually appeared shortly thereafter.

This suggests that these two species have a home range and remain associated with a given area for extended periods.

There is also evidence that fidelity to a given site by *A. laevis* may last for long periods. A large number of this species was noosed for filming purposes and sustained injury to the skin of the neck as a result. A visit to the same locality a year later revealed the presence of many snakes with scars around the neck.

Within their home range, snakes do not always return to exactly the same spot for their inactive periods, however, as indicated by the following field notes:

Scotts Reef, Timor Sea, 8 Jan 1973, daytime, H. H. *"A. duboisii* found coiled on sand by dead coral in 3.5 m of water; motionless for 16 min 35 sec, then started to gradually move head and body slowly; ascended to surface for one breath, dived straight to a flat brain coral about 2 m from previous location; coiled in crevice at base." Similar observations of change in shelter site have been noted above (see notes of 2 May 1968, Jan 1973).

The distance covered while foraging between breaths undoubtedly varies with species and with condition of the habitat. The values obtained in the present study ranged up to about 500 m during a given submergence; many smaller values, of only 10-15 m were also recorded. A map of the movements of an *Aipysurus laevis* which was continuously followed for 26 minutes is presented in Figure 6.

The senior author is now engaged in a mark-recapture study with the objective of studying movements of snakes on coral reefs.

DIVING AND SURFACING BEHAVIOUR

As indicated by various of the excerpts from field notes quoted above and by numerous other observations, sea snakes in the sea commonly ascend to the surface to breathe (Fig. 7) take one breath and then immediately return to the bottom. This is by far the most common behaviour pattern during the day; rarely, more than one breath is taken before returning to the bottom. On some occasions the momentum of ascent carries the snake's head and part of the neck well above the surface of the water. Breaths are often audible to a person above the surface. Occasionally, exhalation begins a short distance below the surface and bubbles can be seen streaming from the snake's nostrils just before it breaks the surface. Generally surface time is very brief, only a few seconds.

Ascent and descent are usually nearly vertical and the journey to the surface or bottom made without interruptions. Several exceptions were noted, however. On 5 Janurary, 1973, an *Acalyptophis peronii,* attached to an XBT lead (for recording heart rate at depth), remained on the surface for 12 minutes, then gradually descended at an oblique angle toward the bottom to a depth of about 12 m, then levelled off at an even more oblique angle toward the bottom; after 5 min of swimming it was lost to sight at a depth of about 37 m. On another occasion (6 Jan, 1973) a snake on an XBT lead leisurely swam at an angle toward the bottom. After 4 min and reaching a depth of 17 m it returned to the surface and shortly dived again, whereupon it went nearly to the bottom (30 m) where it was captured and retrieved. It is probable that both the angle and rate of diving was influenced by the fact that the animal was tethered, even though the XBT wire was extremely fine.

The rate of ascent or descent of 5 individuals was measured (Table 2). In most cases the rate was 0.30-0.36 m/sec. One individual ascended much faster (0.60 m/sec) and one dived much more rapidly (0.90 m/sec). Most snakes which were observed, but which were not specifically timed seemed to dive and surface at about the same speed as the three slower animals in Table 2. Hence 0.30-0.40 m/sec seems a good general estimate of diving and surfacing speed of sea snakes, with the qualification that they are capable of and sometimes employ speeds double or triple that rate. Most snakes seemed to dive at the same speed at which they surfaced.

Surface-active snakes vary in their behaviour, depending on how long they have been on the surface. At first they are reluctant to dive when approached and are more easily captured than when they have been on the surface for some time. Nocturnally surface-active *Hydrophis melanocephalus* and *Acalyptophis peronii* tended to remain on the surface for 10 to 20 minutes.

In the sea, it was difficult to tell when surface-active snakes breathed. However, in the laboratory snakes on the surface undergo prolonged periods of apnea, comparable to the submergence times of snakes that return to the bottom between breaths (Heatwole and Seymour 1975a); it is likely that surface-active snakes in the sea are also apneic most of the time.

Table 2. Rates of ascent and descent of individual sea snakes in their natural habitat.

SPECIES	WATER DEPTH (M)	TIME TO ASCEND OR DESCEND	M/sec
ASCEND			
Aipysurus duboisii	3	5	0.60
Aipysurus fuscus	6	20	0.30
DESCEND			
Emydocephalus annulatus	6	18	0.33
(two individuals)	4	11	0.36
Aipysurus laevis	9	10	0.90

The mode of locomotion is usually typically sinuous and serpentine. One unusual aspect it that some sea snakes (and also the file snake, *Acrochordus granulatus)* can swim backward as well as forward by reversing the direction of the lateral undulations of the body. This behaviour seems especially well developed in *Pelamis platurus*. In a laboratory tank one sometimes has to look carefully in order to ascertain which is the head end of a swimming snake.

On one occasion an *Aipysurus duboisii* which had surfaced remained vertically in the water, with the head and about 5 cm of the neck protruding above the water, and using a sculling movement propelled itself backward in the water, all the time facing the observer.

SHEDDING

There are reports in the literature that sea snakes do not shed the skin whole as do land snakes but rather lose it piece by piece (e.g. Loveridge 1946). Other reports indicate that the whole skin is shed. We have had many snakes of a number of species shed their skin in the laboratory and always the skin was shed whole; in the field we have seen snakes with torn skins but never any that shed piece-meal. We have kept no data on the frequency of shedding. On 1 July 1971, 2 of the 20 *A. laevis* seen on a dive on Saumarez Reef, Coral Sea, were shedding or had the eyes cloudy (an indication that shedding is imminent, see Figure 8) an incidence of 10%. At Swain Reefs in November 1976, 85 snakes were captured over a two-week period; 4 (5%) were shedding. We have never observed snakes with cloudy eyes foraging. They usually lie quietly on the bottom, moving only to surface for air; some were heavily covered with algae.

We have observed snakes shedding in the sea; the following excerpts from field notes describe the process:

Saumarez Reef, Coral Sea, 2 July 1971, 1345 hrs, H. H. "*A. laevis* observed on bottom on patch of dead coral rubble in 10 m water. Its behaviour appeared unusual so it was not immediately caught. It rubbed its head against the dead coral and loosened the skin around the mouth; it continued to rub the sides of the head and the chin on the rubble as it slowly swam along; during rubbing it turned sideways and bent its neck as it scraped the side of the head against the substrate; after head skin was peeled back, it continued rubbing venter and sides of the neck and body against bottom until its skin peeled (entire) back from the anterior ¼ of its body. This took about 5 min. Animal then captured."

Fig. 6. Map of the path followed by a foraging *Aipysurus laevis* in the Swains Reefs, Coral Sea.

Fig. 7. An underwater view of *Aipysurus laevis* at the surface with its head out breathing. Photograph by Harold Heatwole.

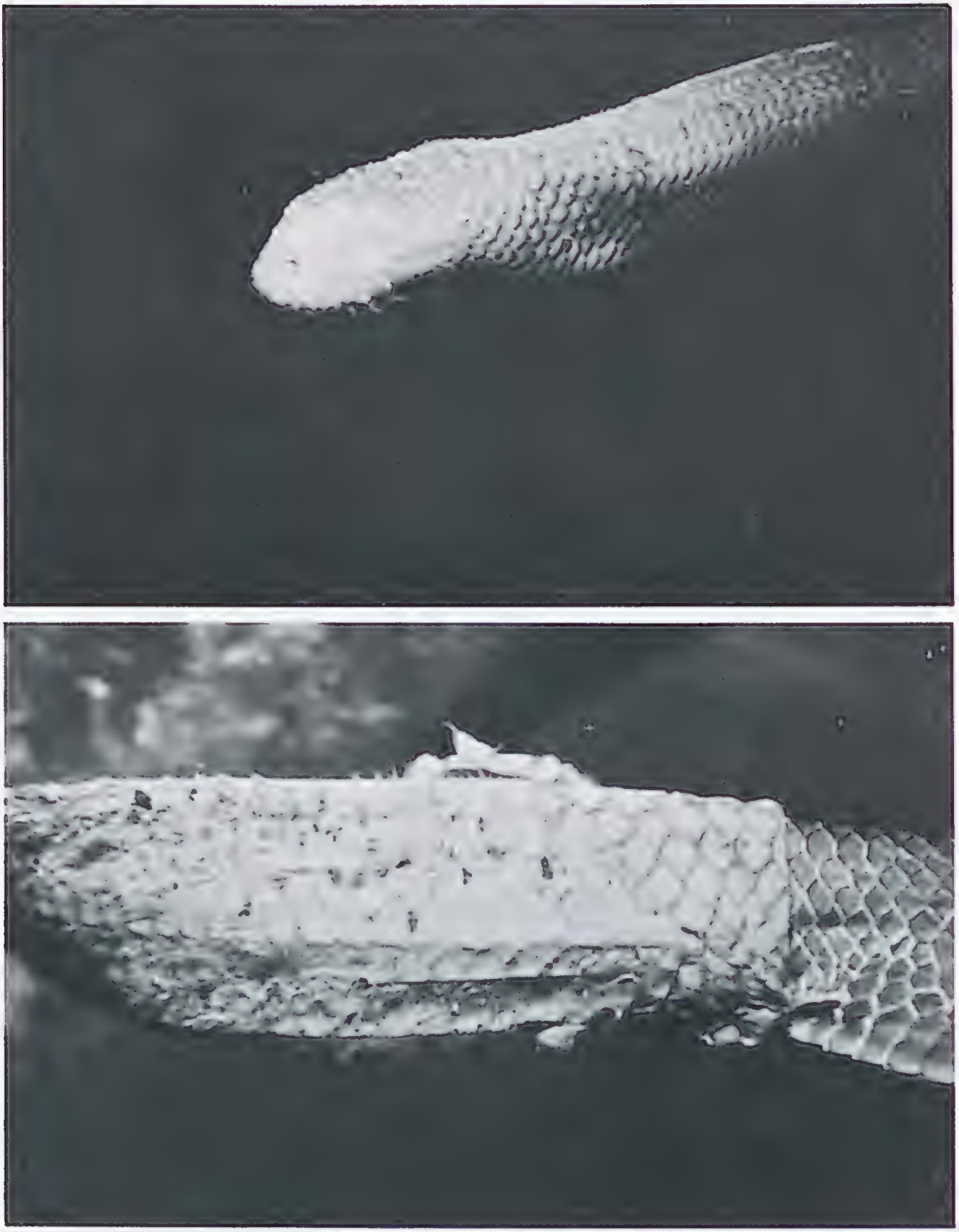

Fig. 8. Shedding in *Aipysurus laevis*. Upper: A snake with cloudy eyes about ready to shed. Lower: Skin (torn) everted over tail of shedding snake. Photographs by Ron and Valerie Taylor.

On 4 July 1971 at the same locality, another *A. laevis* was similarly observed. It was captured when the skin of the anterior half of the body had been turned inside out and extended back over the posterior half. See also Figure 8.

The shedding of *Pelamis platurus* has been described by Pickwell (1971). He indicated that knotting and coiling by *P. platurus* aids in freeing the skin (intact) and must be an advantage to a surface-dwelling animal where solid objects for scraping against would not be abundant (and would give when pushed against). We have observed knotting and coiling during shedding of *P. platurus* in a large laboratory tank and in addition have observed a previously unreported mode of loosening the skin. The following notes illustrate the procedure:

"Snake first observed with anterior ¼ of skin free; it frequently swam backward, then forward; the drag of the water on the loose skin seemed to aid in loosening the skin from the body; the snake also knotted, rubbed against other snakes, the side of the tank and the outlet tubes; at frequent intervals the girth of the body was momentarily locally expanded at the boundary between loose and adhering skin. The expanded area was only about 2 cm long and resembled a large food bolus; expansion repeatedly occurred always at the place where the skin was being loosened. Consequently the site at which the bulge would appear shifted posteriorly during shedding. After 5½ min the skin was ½ off and turned inside out over the posterior part of the body; the snake then became inactive; later, the completely shed skin was recovered from the tank; it was all in one piece, turned inside out except for the posterior part of the tail."

The mechanism whereby the local bulge was produced was not ascertained but its function was clearly aiding loosening of the skin.

May and Nickerson (1968) noted that the sea krait *Laticauda semifasciata* in captivity shed the skin entire and that ecdysis was accompanied by knotting and coiling; immediatley before and during shedding the animals individually floated at the surface in a "tight ball." They also mention that shedding was facilitated by expanding the body by increased air intake although they do not specify that the expansion was localized in their species. Brief field notes on this species are also available.

Gigantes Island, Philippines, 12 Sept 1975, S.A.M. "Area of very beautiful and diverse coral growth; maximum depth about 15 m. Caught 2 *Laticauda semifasciata* each about 1 m long curled around coral clumps. One was shedding its skin . . . most of the skin came off as it was caught and brought to the surface."

One function of shedding may be to remove sessile organisms that attach to sea snakes, such as algae, foraminiferans, hydrozoans, perpulid polychaetes, some bivalve molluscs, bryozoans, barnacles and ticks which sometimes are found on sea snakes (Zann *et al.* 1975). Most sea snakes are relatively free of such fouling organisms although occasional individuals are found with heavy infestations (Fig. 9), and one species of barnacle is restricted to sea snakes (Zann 1975). An individual of *Aipysurus laevis,* taken at Heron Island on a fishing line had a goose barnacle on each eye, rendering it completely blind (Cogger, personal communication). Of 85 *A. laevis* caüght on Swain Reefs in November 1976, only 3 had heavy algae infestations.

SOCIAL INTERACTIONS

There is both interspecific and intraspecific variation in aggressiveness of sea snakes toward humans (Heatwole 1975b) and it would be surprising if interaction among snakes themselves did not show similar variability. However, in most cases sea snakes seem to pay little attention to each other. In the field sea snakes usually are solitary. Where they

Fig. 9. An *Aipysurus laevis* with a heavy covering of algae. Photograph by Ron and Valerie Taylor.

come into close proximity with each other, presumably by chance, they usually do not respond overtly to each other. On a number of occasions, we have seen foraging snakes pass close to a resting one without either showing any signs of response. The following field notes illustrate this point:

Ashmore Reef, 4 Jan 1973, S.A.M. "While watching an *Aipysurus laevis* swimming along a coral trench at 4-5 m, saw it encounter an *A. duboisii* of about the same size. Neither snake responded to the other."

An exception occurs in the mating season. Notes by S.A.M. indicate that on 3 Jan 1973 a (uniformly dark) snake was seen moving along the bottom at a depth of 6 m. It located a second (variegated) snake under a coral ledge and began rubbing its head over the head and neck of the other. The pair swam slowly together around a small coral clump for about 10 min, one individual (presumed male) swimming above and slightly behind the other (presumed female) (see also Fig. 2 in Heatwole 1975b). Later in the day similar behaviour was observd in another pair of snakes at a depth of about 4 m. Again the presumed male located the presumed female under a clump of coral, rubbed her head and neck with his head, and followed her closely until she surfaced to breathe. He did not follow her but resumed contact with her after she returned to the coral. Soon afterwards he broke off contact and swam away. On 11 and 12 of January 1973, several other courting pairs were observed and sex of some was verified by capture and examination. In one instance the male voluntarily followed the captured female almost to the surface. In one case the male rubbed the neck and back of the female with his nose and may have bitten at her as they were lying on the bottom in water about 7 m deep. He lay with his body closely pressed against her back and attempted to work his tail under hers (Fig. 10). All courtship behaviour observed took place near the bottom. Although two divers (S.A.M., H.H.) frequently observed courtship in *E. annulatus* at Ashmore Reef, in no case was a complete copulation seen.

Courtship was very similar in *Aipysurus laevis* (Fig. 10; also see photo in MacLeish 1972). Pairs swimming together much as described above for *E. annulatus* were observed from time to time in the Coral Sea. Courtship could be induced in the mating season by towing dead snakes through the water. A hole was pierced through the upper and lower jaws near the midline of a dead *A. laevis* and a transparent, nylon fishing line passed through the hole and tied fast; the line extended about 40 cm below the snake and had a sinker attached to keep the snake near the bottom. The other end of the line was extended to the surface where a snorkeler slowly swam, towing the snake along. The forward motion, in conjunction with the sinker dragging on the bottom, resulted in a life-like sinuous swimming movement by the dead snake. Excerpts from field notes during such experiments are instructive:

Saumarez Reef, Coral Sea, 3 July 1971, 1100 hrs. H.H. "An adult *A. laevis* sighted swimming about 25 cm off bottom over sand and dead coral in 10-12 m of water. I towed a dead *A. laevis* about ½ m above the bottom on an intercepting course with it. It swerved to it and bumped its nose along the side (smelling with tongue?) and followed it moving along the side and swimming above it in close proximity until its snout was just behind the head of the dead snake. It moved up and back, at times swimming with its snout at the tip of the dead snake's tail and at other times with its head at more anterior locations, up to the base of the dead snake's head. It followed the snake for about 75 m. When I stopped towing the dead snake, the live one would stop also and eventually turn away. When I resumed towing the snake, the live one returned and followed it again. The snake surfaced to breathe, noticed me, came over and had to be repeatedly repulsed; it thereafter refused to follow the dead snake." Similar behaviour toward towed dead

Fig. 10. Pair of sea snakes courting. Upper: *Emydocephalus annulatus* at Ashmore Reef. Photograph by Sherman Minton. Lower: *Aipysurus laevis*. Photograph by Ron and Valerie Taylor.

snakes was observed on a number of other occasions on several expeditions during the mating season of *A. laevis*. *Emydocephalus annulatus* showed no overt response to a towed *A. laevis*.

No complete copulations were ever observed. On several occasions a pair was interrupted in what was probably copulation. However, during courting and mating *A. laevis* tends to be aggressive toward humans (Heatwole 1975b) and behaviour was altered by the approach of an observer. Mating by a pair of *Aipysurus laevis* on the bottom was observed. When the pair was approached, they attempted to separate, both swimming away, the female dragging the male which still had the hemipenis inserted (Fig. 11).

REACTIONS TO OTHER SPECIES

Small fish sometimes associate with sea snakes as indicated by figure 12 and the following notes:

Ashmore Reef, 3 Jan 1973, S.A.M. "At about 7 m depth saw an adult *Astrotia* cruising along just above the bottom. Around its head was a group of about 8 tiny black and gold fish. After I captured the snake, they remained around me swimming usually just in front of my mask for about 15 min." C. J. Limpus (personal communication) indicated that the fish in the photograph "appeared to be identical to the juvenile golden trevalley *Caranx speciosus* (Forskal) which I am observing with my sea turtles and others are seeing with sharks, etc."

One diver on the Ashmore Reef expedition reported cleaner fish attending sea snakes the way they do large fish.

Although sea snakes are preyed upon by a few species of sharks, especially the tiger shark, *Galeocerda cuvieri* (Heatwole *et al.* 1974, Heatwole 1975c) most sharks pay little attention to sea snakes and R.T. and V.T. have observed *Aipysurus laevis* swimming among packs of feeding sharks without the snakes being molested.

Response to humans varies interspecifically and according to season, reproductive condition of the snakes, and the behaviour of the person (Heatwole 1975b). Some species never attempt to bite even when maltreated although most will bite defensively; a large number of fatalities from sea snake bite occur each year in southeast Asia (Reid 1975, Vick *et al.* 1975). A few species will attack a person if sufficiently provoked and occasional unprovoked attacks by *Aipysurus laevis* have been recorded. This species, however, often either ignores humans in the water or swims away when molested. If undisturbed, these snakes will often approach a diver and investigate him. They seem to be attracted by divers' activities and frequently associate themselves with persons underwater, sometimes following them around. In November 1976, metal tags were affixed to the tails of 85 sea snakes on Swain Reefs; only 3 of these attacked divers and two of these did so only after they had been released after having had their tails pierced by the tags. On some occasions when we have stirred up the bottom they appeared to be feeding on small items dislodged from cover. One of us (V.T.) has fed *A. laevis* by hand on small chunks of fish during the day and another (H.H.) has fed this species at night (see section on feeding). In the former case, when the morsel was held out, the snake approached, and after touching the cut piece of fish with its tongue several times, ate it from the diver's fingers.

On one occasion a snake surfacing, presumably to breathe, saw a diver and when about 3 m below the surface changed its course and approached the diver and followed her to the bottom and remained with her for a further 15 min. without resuming its trip to the surface.

Fig. 11. A pair of *Aipysurus laevis* interrupted during copulation. The female is towing the male through the water by the still-inserted hemipenis. Photograph by Ron and Valerie Taylor.

Fig. 12. An *Astrotia stokesii with a group of juvenile Caranx speciosus* swimming above the neck region. Photograph by Sherman Minton.

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BALOF SHELTER, NEW IRELAND — REPORT ON A SMALL EXCAVATION

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SUMMARY

The excavation of 6 m^2 from a rock shelter in New Ireland is described. The maximum depth of deposit was 80 cm, with no clear strata being visible. A radiocarbon date of 6-7,000 years b.p. was obtained from the lowest levels, and one of 2,500 years b.p. from the middle. Faunal materials recovered include mammals (all except one still extant), lagoon fishes, reptiles and shellfish, the last being primarily from reef and lagoon environments. Artefacts from earlier levels include bone bi-points, flaked stone tools patterned similarly to those from the New Guinea Highlands and made from stone from a variety of resources, and obsidian imported from Talasea, New Britain. Obsidian from the Lou (Admiralty Is.) source, and pottery date from about 2,500 years ago. The site is the oldest so far excavated in Melanesia, and data from it provide insights into the development of trade patterns in the area over the last 7,000 years.

1. SITE, STRATA AND DATING

SITE AND EXCAVATION

Balof shelter is situated about 1.5 km inland from Medina village, on the east coast of New Ireland, some 90 km from the northern end (Fig. 1).

The coastal strip around Medina is only a few hundred metres wide and the country then rises in a series of irregular terraces, each of which is a few hundred metres across and possesses a steep and sometimes partially cliffed front. Balof shelter is located in the face of one such front, the third above the current coastal strip. It is estimated to be some 60-75 m above sea level.

The cliff at the point where the site is formed has been eroded and dissolved (possibly post-elevation) into an almost circular cavity some 50 m across at the base, which itself has been somewhat undercut to form a series of shelters. The largest and driest of these cavities is on the northeastern side, where the protected area is some 25 x 6 m. This is known locally as Balof (Fig. 2). The other shelters around the cavity are damp, while the cavity centre is filled with lianas hanging from the surrounding bush and a few trees.On the eastern side one scrambles over a pile of boulders to reach the main terrace surface from which it is a fairly easy walk to the beach.

Records of The Australian Museum, 1978, **Vol. 31 No. 19,** 000-000, Figures 1-13

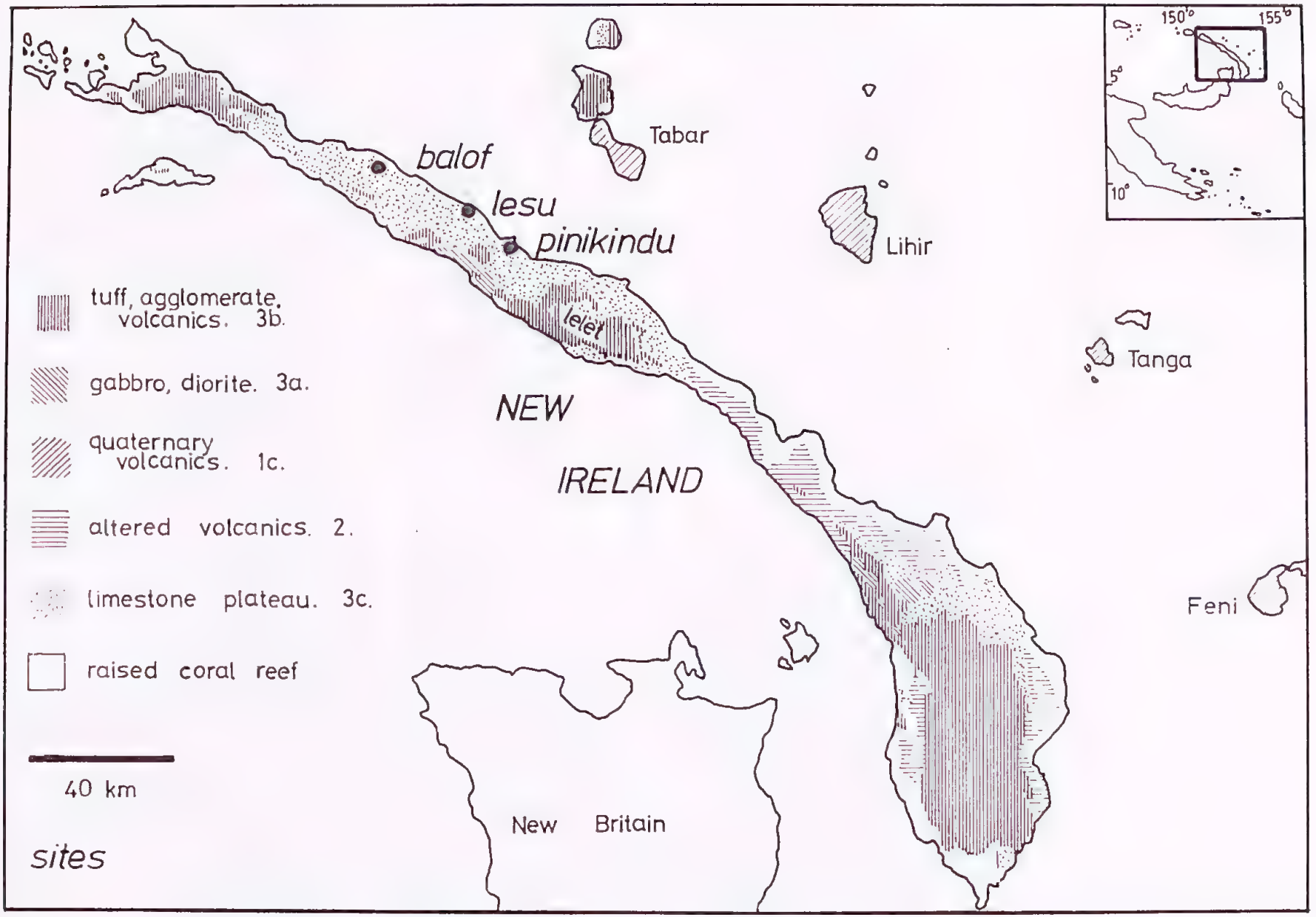

Fig. 1. Map of New Ireland showing sites mentioned in the text and geological features.

Fig. 2. Balof site from the east. Human figures give scale.

Evidence of human use of Balof came from material lying on the surface. Broken gramophone records, clearly 78 r.p.m., but of unidentifiable titles, confirmed local statements concerning its use in the 1939-45 war, while snake and rat bones, fire hearths and limestone slabs used in pit cooking also suggested use within the same period.

Local informants, especially Sanaila, whose gardens were on the terrace in front of the site, believed it had been occupied in pre-European times by people whose more permanent residence was further inland. This belief conforms with population history of the area in that the interior was inhabited in the late nineteenth century, whereas today it is not. Sanaila's belief has not been checked archaeologically.

To commence the excavation a base line was laid out and a datum point fixed on the cave wall. The site was gridded into one metre squares, lettered east-west and numbered north-south. Six square metres were excavated, with squares C3 and D3 being set 50 cm north of their true position to avoid rockfalls (Fig. 3). Surface levels were between 20 and 37 cm below datum.

As there were no well-defined strata apart from a large pit near the surface (see below) the deposit was removed in arbitrary spits some 10 cm in depth. In the absence of visible zonation, we have assumed that there is a direct correlation between depth below surface and age of the deposit, so that spits the same depth below the surface have been correlated for analysis. In all, eight spits were excavated, clayey red-brown cave earth being reached some 107-112 cm below datum. This clay appreared to be completely sterile, and the removal of 60 cm confirmed this.

All excavations were carried out by JPW, the excavated material being sieved by local labour through 6 mm mesh. Sieves were checked before material retained by them was disposed of. In the following analyses spits are designated (1) — (8) following a square code, and sets of correlated spits are labelled levels I-VIII.

STRATIGRAPHY

The top 3-5 cm consisted of hard-packed, damp, grey ashy soil, with patches of lighter ashy material. It contained recent artefacts. Below this level there was soft grey soil with some limestone grits and rubble. Apart from a few thin lenses of darker or lighter soils, with ash in the first 3 spits (26 cm below surface) in E3, no soil changes were seen in the deposit until the clayey red-brown cave earth was reached (Figs. 4, 5, 6).

In squares E4-5 there was a large pit approx. 1 m across with a maximum depth of 25 cm. This contained much carbon and ash, along with burned soil and limestone cobbles. This is probably a cooking pit, although present day custom does not require the digging of such a large pit. It appeared to be dug from the base of the surface layer.

Several postholes were found in the surface level and four in level III. Three of the latter contained remains of wooden stakes, two of which had been burned.

The other major feature was a large rock-fall in E3 which first appeared in spit (3) and gradually enlarged to occupy most of the square by the time spit (6) was reached. Considerable quantities of shell and bone were found beside this rock, suggesting that its sides may have been used as a convenient rubbish-dumping location. Another large rock, which may be bedrock, occurred in the northeast corner of E6.

Fig. 3. Plan of Balof, showing location of excavation. Fig. 4. Excavation, showing stratigraphy.

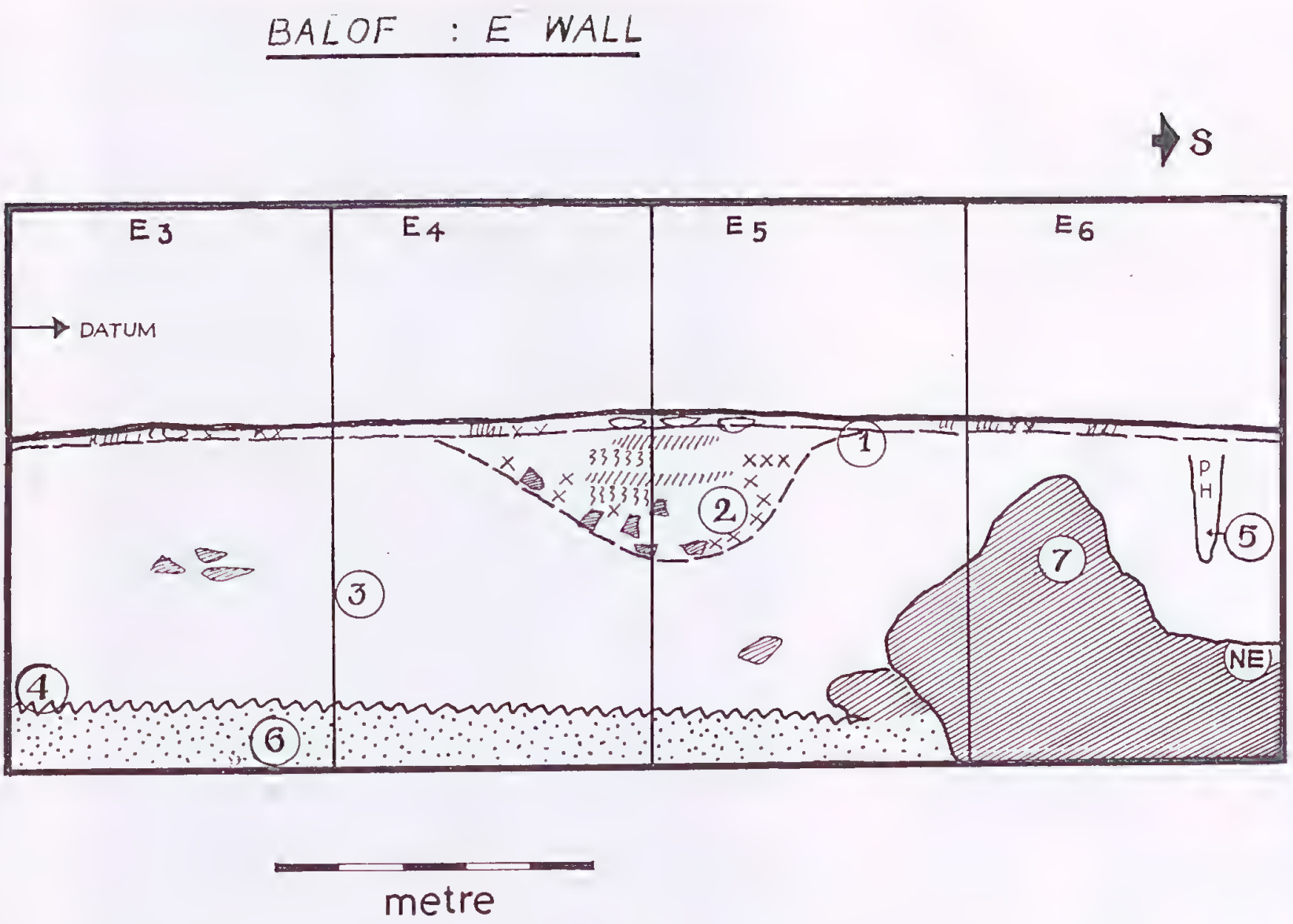

Fig. 5. Balof: section along east wall of squares E3-E6. (1) Hard packed surface, with traces of white ash and carbon; (2) pit, with stones (shaded), carbon (xx), white ash (//) and lighter, burned soil; (3) undifferentiated dark brown soil; (4) mixed transitional zone between (3) and (6); (5) post-hole; (6) red-brown sterile cave earth; (7) rock; (NE) not excavated.

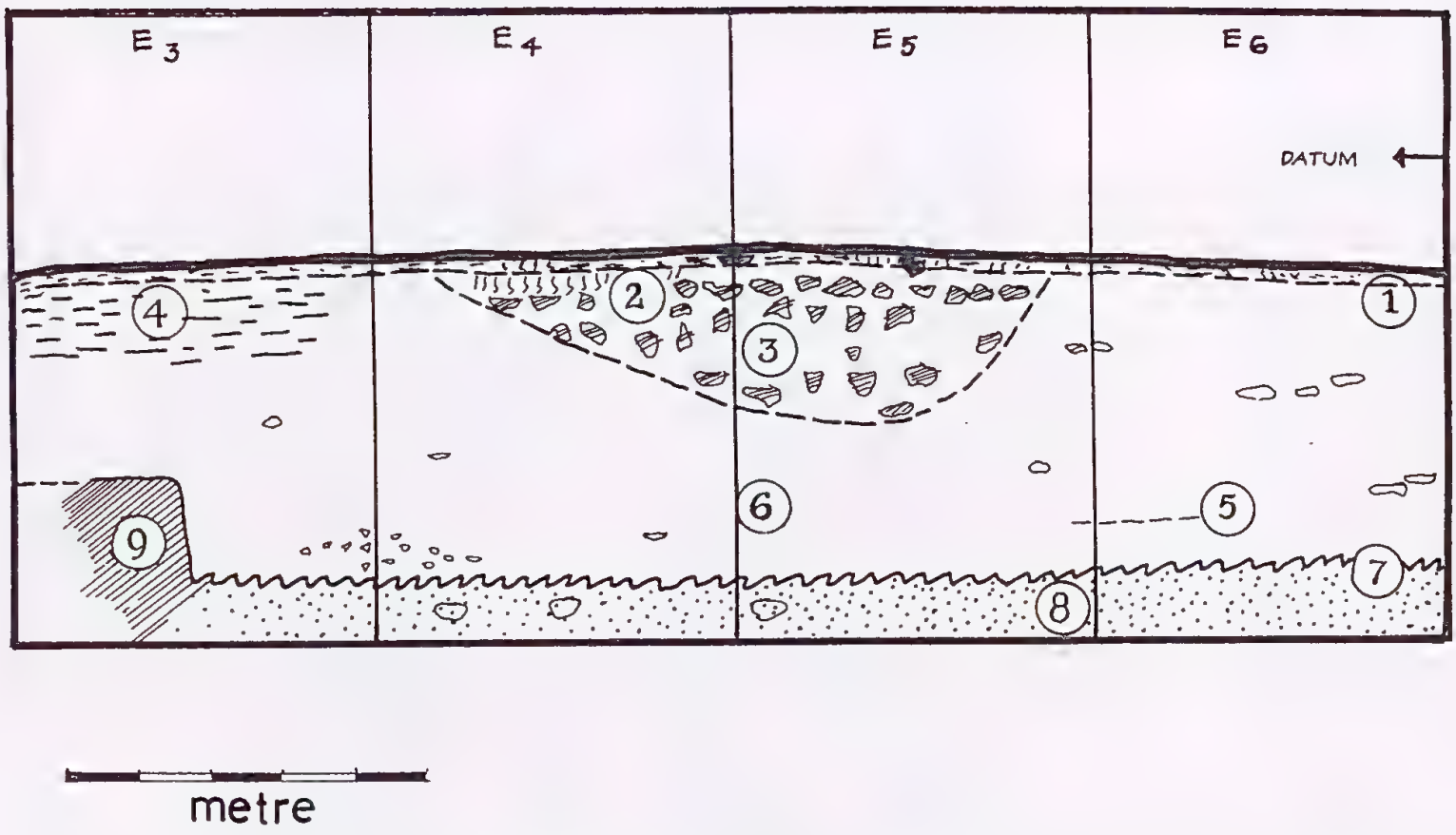

Fig. 6. Balof: section along west wall of squares E3-E6. (1) Hard packed ashy surface; (2) light brown ash; (3) pit, consisting of soft blackish soil with many burned limestones and much carbon; (4) thin layers of darker and lighter soil with some ash; (5) irregular concreted flowstone; (6) undifferentiated soft dark brown to grey soil with occasional limestones; (7) mixed transitional zone between (6) and (8); (8) red-brown sterile cave earth; (9) rock.

Although shell and other occupational debris occurred throughout the deposit, along with some burned limestone cobbles, there was little evidence of hearths or carbon below level III. It seems likely that human treadage and scuffage of the surface of a slowly accumulating deposit (see Dating) has rendered such evidence undetectable.

The sequence of events at Balof was probably as follows: the cave was initially an underground dissolution cavity, in which the clayey red-brown earth was deposited. Subsequent collapse opened it at the top and sides, making human use possible. Deposits accumulated from further disintegration of the cave, some washed or blown-in material, and humanly-derived debris, with the latter always accounting for a high proportion of the total.

DATING

Two radiocarbon dates were obtained.

GaK2437 1540 ± 270 b.p. (half-life 5730).

This date comes from scattered lumps of charcoal 17-23 cm below surface in spit (3), and found over two-thirds of square D3. The sample consisted of fingernail-sized lumps which were collected on a knife point and stored in new plastic bags.

Both the scattered nature of the sample and the problems of surficial deposit re-working suggest that this determination should not be taken as more than a general indication of age, although probably one of minimum age. Nonetheless, it was this determination which originally enabled the prediction that the earliest use of the site should have occurred some 6000 years ago, assuming a reasonably constant rate of deposit accumulation (White 1972b). Since such an age would be older than for any other well-dated site east of the main island of New Guinea, further testing seemed essential, but the absence of charcoal in the lower part of the site made this difficult.

NSW95 ⩾6600 ± 400 b.p. (half-life 5568). Corrected to a half-life of 5730, this date becomes ⩾6800 ± 410 b.p.

This date comes from the acid insoluble fraction of 553 gm of bone from spits (7) and (8) in squares C3 and D3. These spits range from 58 to 84.5 cm below surface. The sample consisted of long-bone shafts and vertebrae of small mammals and reptiles.

We believe that this age is approximately correct, since it is in reasonable accord with the earlier prediction, and there are, as will be seen, good reasons in terms of the archaeological materials for believing in its approximate accuracy. But, because of the sample size, the area over which it was collected, and the problems of dating bone fractions, this date cannot be relied on for more than a general indication of the age of the deposit.

2. FAUNAL MATERIAL

SHELL

About 12.75 kg of shells and fragments were recovered from the excavation. This material was found in every level, although amounts in I and II were low, while nearly 30% occurred in VII. There was also some variation in the areal distribution (Tables 1-3). This material has not been fully analysed in scientific taxonomic terms, both because of the considerable difficulties involved and also because its primary interest for this study is in terms of the record of environmental exploitation it gives. Thus, following initial sorting

of the shell into clear morphological categories, Dr. W. Ponder (Curator of Molluscs, The Australian Museum) was asked to suggest from which local environments the shellfish were originally gathered.

Table 2 shows the weight of shells obtained from each environment, and Table 3 expresses these figures as a percentage of the total after the removal of shells occupied by hermit crabs and unidentifiable opercula.

Table 1. Distribution of Shell (%)

C3	D3	E3	E4	E5	E6
21.0	15.5	11.6	32.0	9.0	10.0

It should be noted that up to one third of all the material cannot be related to environmental categories. As well as a number of *Nerita* shells which had been inhabited by hermit crabs and opercula which are difficult to relate to particular gastropods, there is a quantity of very broken shell. We suspect that lagoon environments provide much of this remnant material since this is where small mussel and oyster varieties, with thin, light shells, are found.

Land snails occur in all levels. There is no ethnographic evidence of their having been eaten in New Ireland and they may be an indicator of site disuse (Clay 1974:7). The shells were, however, mixed in with other occupational debris and were most common in levels which contained large numbers of other shells, which suggests that some use was made of them.

Some littoral environments show a regular but very low level of exploitation throughout the site's use. These are semi-exposed dead coral (chitons only) and reef top areas (limpets only): it is likely that these shellfish were gathered in passing, in the course of other reef and lagoonal collecting.

Table 3 shows some variation in environmental exploitation over time. In the lower levels (V-VIII) shells from hightide splash levels, especially *Nerites*, predominate. The only other common varieties of shells in these levels are bivalves from the mangrove environment. These however, increase in level IV and above, as do shells from fringe mangrove, lagoon and reef. There is some areal variation in the distribution of this material within the excavation and it may be that both this and the variation between levels indicate the chances of refuse disposal in this corner of the site rather than larger-scale causes such as local environmental change or economic reorientation of the collectors. But we note also that the change in shellfish environments comes at a time when other changes occur in the site, so that some degree of cultural preference may also be involved. A larger sample of material might solve this problem.

BONE

About 4 kg of bone were recovered from the excavation. All bone material was fragmentary and some of it was burned.

Initial sorting and indentification of mammalian material was done by JPW and further preliminary work on cranial material only was carried out by P. Thompson (then of

the Archaeological Service Section, Australian Museum). In 1975 Dr. J. Hope (Dept. of Prehistory, A.N.U.) identified some of the post-cranial material. Assistance with reptile identification was given by the Dept. of Herpetology, Australian Museum.

Minimum estimated numbers of animals are listed in Table 4. For all mammal, reptile and fish remains numbers of animals are taken as equivalent to the largest number of identifiable body parts (jaws, particular teeth, etc.) within each square and spit. Crab numbers are based on claws (pincers) (actually half-claws), four or less in any square and spit indicating one animal. Sea urchins were identified by spines, any number within any square and spit being counted as one: there were never more than a few spines within any one unit.

Table. 2. Weight of Shell by Level, Sorted According to Environments of Origin (gm)

LEVEL	S.E.D.C.R.	Lagoon	Outer Lagoon Reef	R.H.T.S.L.	Outer Lagoon	Reef	Reef Top	B.E.I.B.	Fringe Mangrove	B.F.W.	Mangrove	Land Snails	Semi Terrestrial	Hermit Crab Inhabited Nerita Shells	Remnant	Opercules	TOTAL WEIGHT OF SHELL PER LEVEL	%
I	4.2	41.4	11.8	26.2	1.8	69.3	1.4	71.4	36.7	.2	125.8	7.9	.4	11.3	37.8	21.6	469.2	3.7
II	11.5	100.4	19.5	77.8	4.8	100.5	3.9	71.2	68.3	1.3	220.2	6.2	3.8	16.2	197.4	36.7	939.7	7.3
III	10.1	201.2	23.7	213.9	32.7	205.7	10.9	101.8	179.4	2.8	428.5	38.4	4.1	30.7	498.2	131.9	2114.0	15.6
IV	27.4	93.2	9.6	296.7	8.9	335.8	19.4	44.6	168.5	8.4	378.5	23.0	2.5	23.7	209.2	77.0	1726.4	13.4
V	13.8	39.8	4.5	532.6	—	42.0	30.3	94.0	28.7	3.3	275.6	29.3	2.3	44.1	106.2	72.8	1319.3	10.3
VI	26.8	15.2	3.6	1170.8	—	12.4	20.2	195.8	18.4	.2	336.7	59.5	17.2	38.0	98.7	21.7	2035.2	15.9
VII	61.3	30.5	4.8	2526.5	3.6	63.1	5.4	367.1	33.0	.7	193.1	78.0	13.2	193.7	121.5	56.1	3751.6	29.2
VIII	7.3	10.4	.2	312.5	—	10.0	2.0	19.0	5.8	—	66.1	7.9	7.9	5.9	32.1	—	486.9	3.8
Total from each environment	162.4	532.1	77.7	5157.0	51.8	838.8	93.5	964.0	538.8	16.9	2024.5	250.0	51.4	363.6	1301.1	417.8	12842.3	

ABBREVIATIONS

S.E.D.C.R. = Semiexposed dead coral rock (chitons)
R.H.T.S.L. = Rocks at high tide splash level (Nerita)
B.E.I.B. = Back end inside beach
B.F.W. = Brackish fresh water.

Table 3. Shell Weight Per Level Gathered From Various Environments (%)

LEVEL	semi-exposed dead coral rock	Lagoon	Outer Lagoon reef	Rocks at high tide splash level	Outer Lagoon	Reef	Reef Top	Back end inside beach	Fringe Mangrove	Brackish fresh water	Mangrove	Land Snails	Semi-Terrestrial	Remnant	Weight in gms: Totals for Levels	Level Totals as % whole
I	1	9.5	2.7	6.0	0.4	15.9	0.3	16.4	8.4	0.5	28.8	1.8	0.1	8.7	436.3	3.6
II	1.3	11.3	2.2	8.8	0.5	11.3	0.4	8.0	7.9	0.1	24.8	0.9	0.4	22.3	886.8	7.4
III	0.5	10.3	1.2	11.0	1.9	10.5	0.6	5.2	9.2	0.1	22.0	2.0	0.2	25.5	1951.4	16.2
IV	1.7	5.7	0.6	18.2	0.5	20.6	1.2	2.7	10.4	0.5	23.3	1.4	0.1	12.9	1625.7	13.5
V	1.2	3.3	0.4	44.3	—	3.5	2.5	7.7	2.4	0.3	23.0	2.4	0.2	8.8	1202.4	10.0
VI	1.4	0.8	0.2	59.3	—	0.6	1.0	9.9	0.9	—	17.0	3.0	0.8	5.1	1975.5	16.4
VII	1.6	0.9	0.1	72.1	—	1.8	0.1	10.4	0.9	—	5.5	2.2	0.4	3.4	3501.8	29.0
VIII	1.5	2.2	—	65.0	—	2.1	0.4	4.0	1.2	—	13.7	1.6	1.6	6.7	481.0	4.0
															12060.0	

Table 4. Estimated Minimum Number Of Animals based on individual squares and spits

	LEVELS								TOTALS
	–	II	III	IV	V	VI	VII	VIII	
Mammals									
Homo sapiens		1	1	1	1		1	1	6
Sus scrofa — pig	1	1	1	1					4
Thylogale brunii — pademelon	2	4	6	4	6	5	1	1	29
Macropus agilis or *Dendrolagus* sp. — wallaby			1*	1*					1
Phalanger orientalis ducatoris sp. — cuscus	6	6	7	9	7	8	8	3	54
Megachiroptera (genera not identified) — flying foxes	3		14	19	17	33	18	11	115
Microchiroptera (genera not identified) — insectivorus bats	2				3	5			10
Rattus exulans or *Melomys rufescens*? — rats	1	3	1		2	3			10
Reptiles									
Scincidae — skinks	2	4	2	3	8	13	16	4	52
Varanidae — monitors		1			1	3	2	2	9
Unidentified Lizards			2	1	1		1		5
Ophidae — ? python	3	3	3	3	7	7	8	7	41
Fish									
Scaridae (identified jaws) — parrot fish			1	1					2
Other fish (spines & vertebrae only; ?parrot or other lagoon type)	2	3		3	2				10
Other									
Elasmobranchii — sharks		1		1	1		1	1	5
Crabs — not identified	4	6	8	9	6	5	6	3	47
Echinoderms — sea urchins	5	6	6	6	2	5	1	1	32

*These bones were found in adjacent levels of the same square and may therefore belong to the same animal.

Homo sapiens. The distribution of these bones is given in Table 5. It is notable that six specimens are teeth and two of the other bones are charred. A number of explanations for the occurrence of these bones may be derived from the ethnographic record and these are listed here, although no testing of any of these explanations can be undertaken.

1. Food remains (Parkinson 1907 [n.d.]:227, 236, 256; Groves 1933:342). The occurrence of charred bones might support this view.

2. Trophy collections, bones being carried around in the hope that powers possessed by the dead person could thus be accrued by the living. (Parkinson 1907 [n.d.] :230).

3. Relicts from compound mortuary practices such as those described by Billings (1971:533-8). For example, bones are retrieved form buried corpses and carried round in a leaf parcel.

4. *Memento mori* (Parkinson 1907 [n.d.] :230). The drilled lunate described below may well have served this purpose.

5. The detritus from tooth evulsion.

Sus scrofa. A list of individual fragments is given in Table 6. The absence of pig remains below level IV is interesting and may be associated with the appearance of pottery at the site (below). However, the excavation is too small to be confident that the oldest pig remains at the site have been found, and other explanations involving changing patterns of site use are also possible (cf. Bulmer 1976). Pigs are nowadays eaten at feasts (Billings 1971:482; Powdermaker 1933:183) and the remains here may result from portions of animals carried from elsewhere.

Other mammals. The range of mammalian material identified is wide. If the list is compared with that of New Ireland species given by Laurie and Hill (1954), then representation of all families, other than *Peramelidae* (bandicoots) and *Mus* are present. Laurie and Hill list nine species of megachiroptera for New Ireland, and although it was not possible to identify our specimens below sub-order level, the presence of a number of different species is reflected in the evidence (J. Hope, pers. comm).

Two post-cranial fragments have been identified as *Macropus agilis* or *Dendrolagus* sp. by P. Thompson. These occur in spits (4) and (5) of square D3, and may therefore come from the same animal. Either of these identifications poses a problem since the nearest known locality for either animal occurring in the wild is mainland New Guinea. It may be that these remains indicate the former presence of one or other species on New Ireland, the animal now being extinct through some cause such as hunting pressure. Alternatively, we may remember that it is a common Melanesian practice to catch and tame young animals and also to transport various kinds of animals from place to place. The direct journey of a live macropod from New Guinea to New Ireland is, perhaps, difficult to envisage, though certainly not impossible, while the association of these specimens with other changes in the site is interesting. However, no explanation can be preferred until we know more about the pre-human fauna of New Ireland.

Fish and other marine creatures. Very few fish bones were recovered, and all, apart from the shark's teeth, were of small, probably lagoon, fishes. A possible explanation for this scarcity is that Balof was used when men were hunting rather than fishing, both of which are male occupations on New Ireland today (Powdermaker 1933:183).

Six shark teeth were found, including three in levels VII and VIII. It is tempting to see in these teeth evidence of the dramatic New Ireland method of lassoing sharks (Parkinson 1907 [n.d.] 258-9; Powdermaker 1933: 172-7) which has been recorded by Powdermaker in this area. The lassoing method is at least four centuries old, judging from an illustration

Table 5. Distribution Of Human Remains

	C3	D3	E3	E4	E5	E6	TOTAL HUMANS
I							
II	Mandibular condyle						1
III			molar	Incisor molar			1
IV		Incisor				distal end R Fibula (charred)	1
V		Metacarpal					1
VI							
VII	Incisor	Patella Incisor Lunate*				Phalange (slightly charred)	1
VIII	1st & 4th cervical vertebrae						1

*Lunate at D3 (7) drilled.

Table 6. Pig Remains

LEVELS	
I	1 premolar
II	3 canines 1 molar 1 fragment of jaw
III	1 unerupted molar 2 incisors 1 intervertebral disc 1 fragment of an intervertebral disc 1 metatarsal 2 phalanges
IV	2 molars

in Abel Tasman's journal (A.D. 1643) showing a canoe with two of the propellor-shaped floats resting on the gunwales, and it would not be surprising if earlier inhabitants of New Ireland were also skilled exploiters of marine resources. Unfortunately all identifiable parts of the gear used in shark catching are made of wood and other perishable organic materials so that direct archaeological documentation of this technology seems unlikely.[1]

While the preparation and cooking of fish, like its capture, is generally a male task, the collecting and cooking of crabs and shellfish is done by women (Powdermaker 1933:168-70, 183), so that women's presence at the site is clearly documented by such remains.

3. ARTEFACTS

SHELL

(i) Arm-rings (Fig. 7a). Two fragments of arm-rings made from *Trochus niloticus* were recovered, from E4 (2) and (3). *Trochus* arm-ring fragments are common in other New Ireland sites (White 1972b:309; Clay 1974:12), and their method of manufacture has been described by Parkinson (1907 [n.d.] :254) and more recently by Clay (1974:12). Arm-rings were frequently used in various kinds of exchanges.

(ii) Tools (Fig. 7b-f). Twenty seven pieces of shell, all from mangrove-dwelling bivalves, showed traces of use as tools (Table 7). One of these was a triangular piece with ochre on the inner side (?a palette), the other twenty six all show signs of sharpening and/or wear. Two formally distinct groups occur: in one the original lip of the shell forms a functional edge (n = 22), while in the other a cut or broken edge of shell has been sharpened for use (n = 4). Two of the latter cases are made from a piece of shell which includes the hinge, which would give it added strength.

[1] It has also been suggested that the remains could come from beached sharks. JED's great uncle, Mr. C. Britter, a professional shark fisherman in Mauritius, has never observed beached sharks, since dead ones are quickly eaten by their voracious and cannibalistic fellows. " . . . this I know about the shark. His bite is worser than his bark" (O. Nash)

It seems likely that these tools are 'unmodified shell scrapers' (Poulsen 1970:41) which can only be detected by the presence of sharpening or wear. The use of shell tools as vegetable scrapers is widely recorded in New Ireland (Powdermaker 1933:179; Billings 1971:230) but the scrapers themselves are not described. Parkinson mentions the use of sharpened shells in scraping the skull and in trepanning (1907 [n.d.] :104-8), and also records the use of a sharply ground shell in finishing off carvings (1907 [n.d.] :251).

Table 7. Distribution Of Shell Tools

LEVELS	C3	D3	E3	E4	E5	E6	TOTALS
I	2	0	0	0	1	0	3
II	0	0	1	0	0	0	1
III	2	0	0	1	0	1	4
IV	0	1	2	1	0	3	7
V	0	1	1	0	1	0	3
VI	1	5	1	0	0	0	7
VII	1	1	0	0	0	0	2
VIII	0	0	0	0	0	0	0
TOTALS	6	8	5	2	2	4	27

BONE

(i) Points. Five whole and twenty broken points were found in levels IV to VIII. All the whole points and five almost whole points were clearly bipoints, while eight of the remainder bore a general resemblance to bipoints (Fig. 8a-q). One clear uni-point was found, in E5 (4) (Fig. 8t). This was made of the broken-off spinous process of a vertebra. One other bone fragment may have been the mid-section of a point. All points, with the exception mentined above, were made of mammalian long bone sectioned along the medullary cavity.

Actual and estimated measurements of all points,along with their location and description are given in Table 8. A rough estimate of the original length of broken points was made by outlining the remaining fragment on graph paper and completing a symmetrical outline for it, making the assumption that all were bipoints. Examination of the mean lengths from each level shows a slight tendency for this to increase through time, but the variation appears insignificant. There is no variation in cross-section with time.

Two points appear to be unfinished, having been cut to shape but with the tips remaining unground (Fig. 8 r-s). As well as indicating the process of manufacture, the presence of these unfinished pieces indicates that the site may have been used for making or repairing artefacts. No waste material was noted, but this would be difficult to distinguish from other bone debris.

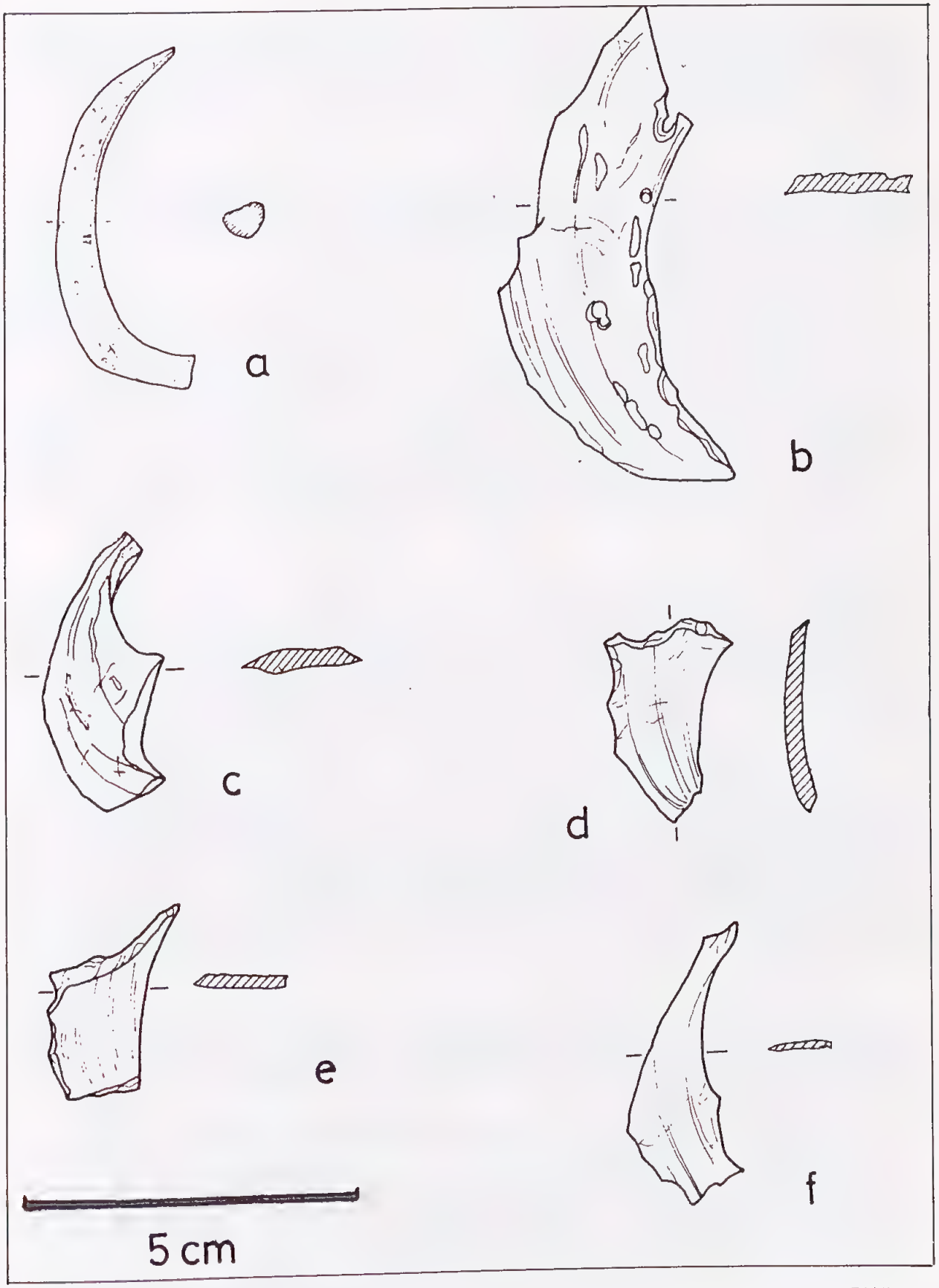

Fig. 7. Shell artefacts. a; arm ring, E6(4); b-f: shell scrapers, D3(6), E4(4), E5(4), E4(6), E6(4).

It is likely that the points were spear or arrow barbs. Comparison with material held in The Australian Museum shows that these points are similar in size to those on a spear from the Bismarcks (E 52765) and on arrows from Bougainville (E 27570, E 60305, E 60306). In the former case however, whole sections of bone were used, and no examples of points made of split pieces of long bone were located among the collections from this area.

The points are too small to have been spear or arrow heads, and the use of fish gorges is not known in New Ireland in the contact period (Anell 1955, 1960). Parkinson (1907 [n.d.] :251) refers to the use of a bone awl in carving, but no further description is given and these points seem too small for this purpose.

Further confirmation of their association with hunting may be seen in the lack of similar points and the rarity of wild animal bones at New Ireland coastal sites (White 1972b:309; Clay 1974:7).

(ii) Pendant? (Fig. 8u). A human left lunate[1] with a hole drilled from both sides was found in D3 (7). The bone comes from an adult of small stature. The hole has apparently been made by cutting into bone from both sides with a sharp instrument, with the centre being finally reamed or drilled out. One side has now been broken out of the hole. Similar artefacts have not been recorded from the region, though Specht (1969:262) found two drilled human pre-molars on Buka. It may be a *memento mori.*

POTTERY

Fifty nine sherds were found in levels I-V. Six of them were broken laterally, so that either the inner or outer surface was missing, and these have not been included in any analyses. The fifty three whole sherds have a total weight of 70 gm and a surface area of 900 mm^2. Table 9 shows the distribution of this material, about two-thirds of which comes from levels III and IV, and nearly 50% of which comes from square E4. Table 9 also indicates that there is no great variation in sherd size throughout the sample.

Two groups of sherds were distinguished on the basis of their temper. A. Fifty-one sherds have a plentiful inclusion of coarse white grains which seem too abundant to be a natural inclusion in the clay. The grains are flat in section and irregularly shaped with rounded edges, suggesting crushed and rolled shell, possibly from a beach. These sherds are soft and crumbly in character. B. Two sherds, one from each of levels II and III, are firm and brittle, with fewer non-plastic inclusions. The grains are fine and rounded, and white in colour. They are probably water-worn sand. It is not clear whether this is natural or added temper.

Sherd colours range from red through brown and grey to black. Many sherds have patchy colouration and some have sides of different colours, a normal characteristic of pottery fired on an open fire. Group A Sherds have grey or black cores which may result from incomplete oxidation.

Four sherds (2 group A and 2 group B) show evidence of wiping while still damp.

Sherds were too small to identify vessel formation technique(s) or to allow vessel form to be reconstructed. However, decoration on the concave side of a level III sherd suggests it may be part of an unrestricted vessel.

[1] For an exact identification we are indebted to Mr. A. B. Bailey, Dept. of Anatomy, University of Sydney.

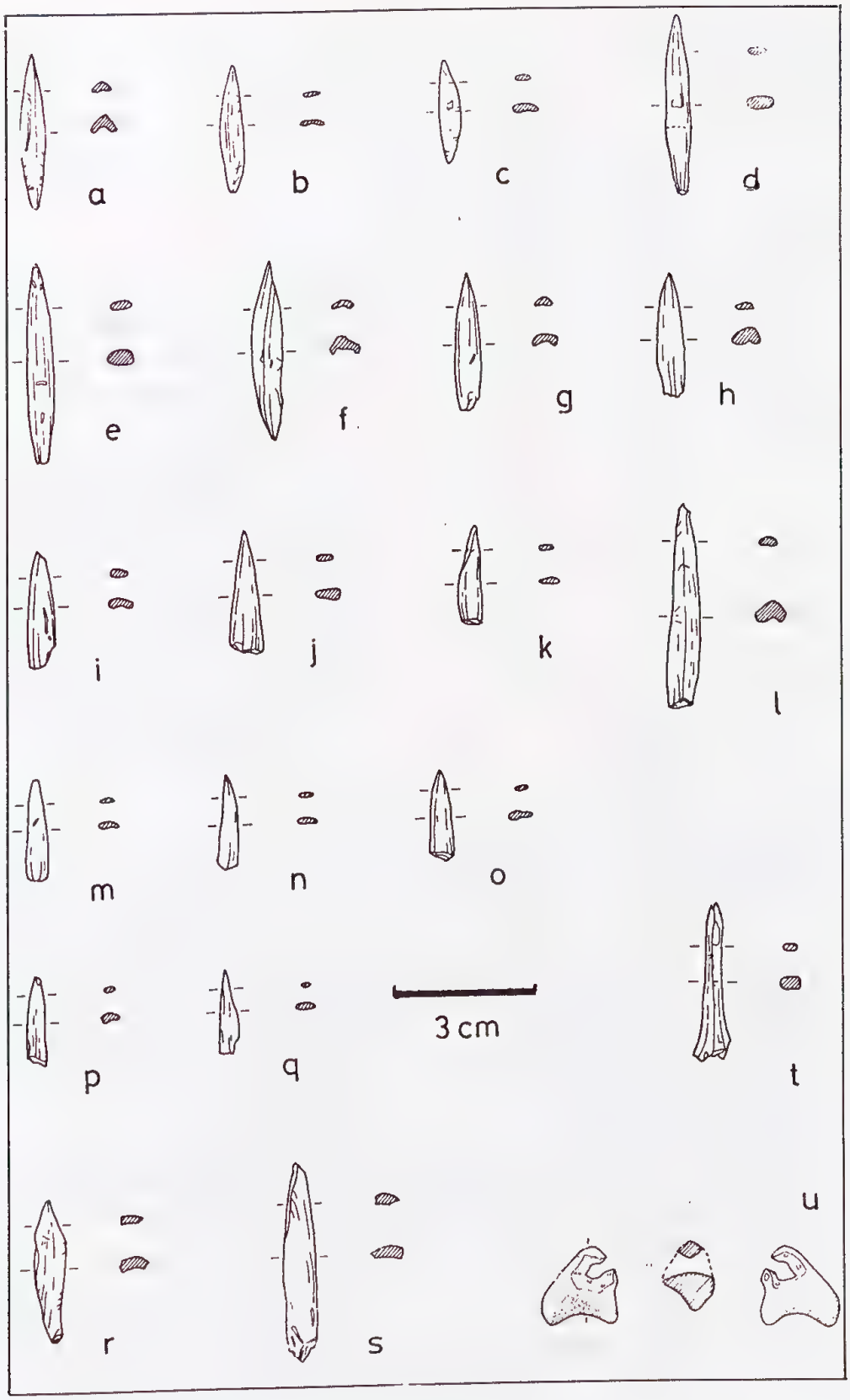

Fig. 8. Bone artefacts. a-q: bi-points; r-s: apparently unfinished bi-points; t: unipoint; u: pendant? See Table 8 for locations.

Table 8. Bone Points

Ref. to Fig. 8	Level	Square	Actual Measure-ments (mm) L B Th	Actual or Estimated Full Length of Whole Points (mm)	Mean actual or estimated length per level (mm)	Cross Section	Condition
		C3	24x6x1	—		Concave	Mid portion?
m		E4	20x5x2	35		Flat	Broken
d*		E5	36x5x2	36		Oval	Complete — found in two fragments
	IV				35		
t		E5	32x5x2	?		Oval	? Complete — Uni-point on spinous process
		E6	17x3x2	30		Oval	Broken. Knife marks both surfaces
i		E6	24x5x2	38		Flat	Broken
s		C3	40x6x2	50		Flat	Broken. Unfinished?
o	V	D3	18x5x2	30		Concave	Broken
b		E3	26x5x2	27		Flat	Almost whole, tip off
c		E3	22x5x1	22	35	Flat	Complete
l		E4	41x6x2	50		Concave	Broken
		E6	24x5x1	35		Flat	Broken
		E3	16x4x2	32		Slight Concavity	Broken
r		C3	29x5x2	30		Flat	Almost whole, tip off, unfinished
g		C3	30x5x2	35		Concave	Broken — end off
n		C3	19x3x1	30		Flat	Broken
f	VI	D3	37x5x3	37	33	Concave	Complete
h		D3	27x5x2	32		Concave	Broken
j		D3	24x6x2	37		Flat	Broken
q		D3	18x4x1	29		Flat	Broken
e		D3	42x5x2	44		Oval	Tip off
k		D3	20x5x2	25		Concave	
	VII				29.7		
		D3	18x5x2	25		Flat	One end and one tip off
p		D3	18x4x2	25		Concave	
a	VIII	C3	33x5x2	33	33	Concave	Complete

*Found with both tips intact — Damage to tip shown in Fig. 9d occurred subsequently.

Table 9. Distribution Of Sherds — Numbers; Weight And Area (% only)

Levels	C3	D3	E3	E4	E5	E6	Totals	Percentages		
								Nos.	Weight	Area
I	—	—	1	—	1	1	3	5.7	8.0	7.7
II	1	—	1	3*	1	2	8	15.1	18.4	17.1
III	2	2	3*	9	2	1	19	35.9	29.7	33.3
IV	2	3	4	8	—	—	17	32.1	28.7	27.6
V	—	—	—	6	—	—	6	11.3	15.1	15.4
TOTALS	5	5	9	26	4	4	53			
Percentages: Nos.	9.4	9.4	17.0	49.1	7.5	7.5				
Percentages: Weight	16.9	12.0	14.7	40.4	7.4	8.6				
Percentages: Area	13.3	9.8	16.1	44.9	8.3	7.7				

(* = Presence of 1 Group B sherd.)

Two rim sherds were found in level IV (Fig. 9a-b). Both fragments are very small, but appear to be from vessels with direct rims. Both sherds have indented lips, the indentations having been made with a thin stick or some similar implement being pressed down into the damp clay.

Four sherds are decorated with incised lines (Fig. 9c-f). Three have one to three fairly deep, U-sectioned incisions which could have been made with a stick, and one has two shallow, slightly wavy and non-parallel lines, clearly incised sequentially. The incisions are irregular in depth and thickness. Table 10 gives data on the decorated sherds. Note that the aspect of the decoration is deduced from the curvature of the sherd.

There is some correlation between decoration and sherd thickness. While half the sherds are only 2 mm thick and only 9 are 4 mm or more thick, three of the four decorated sherds come from the latter group. This may simply indicate that pots were of variable thickness and the thicker part was selected for decoration.

These sherds may be compared with those recovered by Clay from a test excavation in rubbish mounds at Pinikindu, 50 km to the south of Balof (Clay 1974). He divides the sherds into three temper groups—

I. Heavily tempered with crushed shell, possibly some fossil shell and coral. Sherds appear over-tempered and are very crumbly.

II. Temper of rolled white sand and other local constituents. These are the "best made" ceramics.

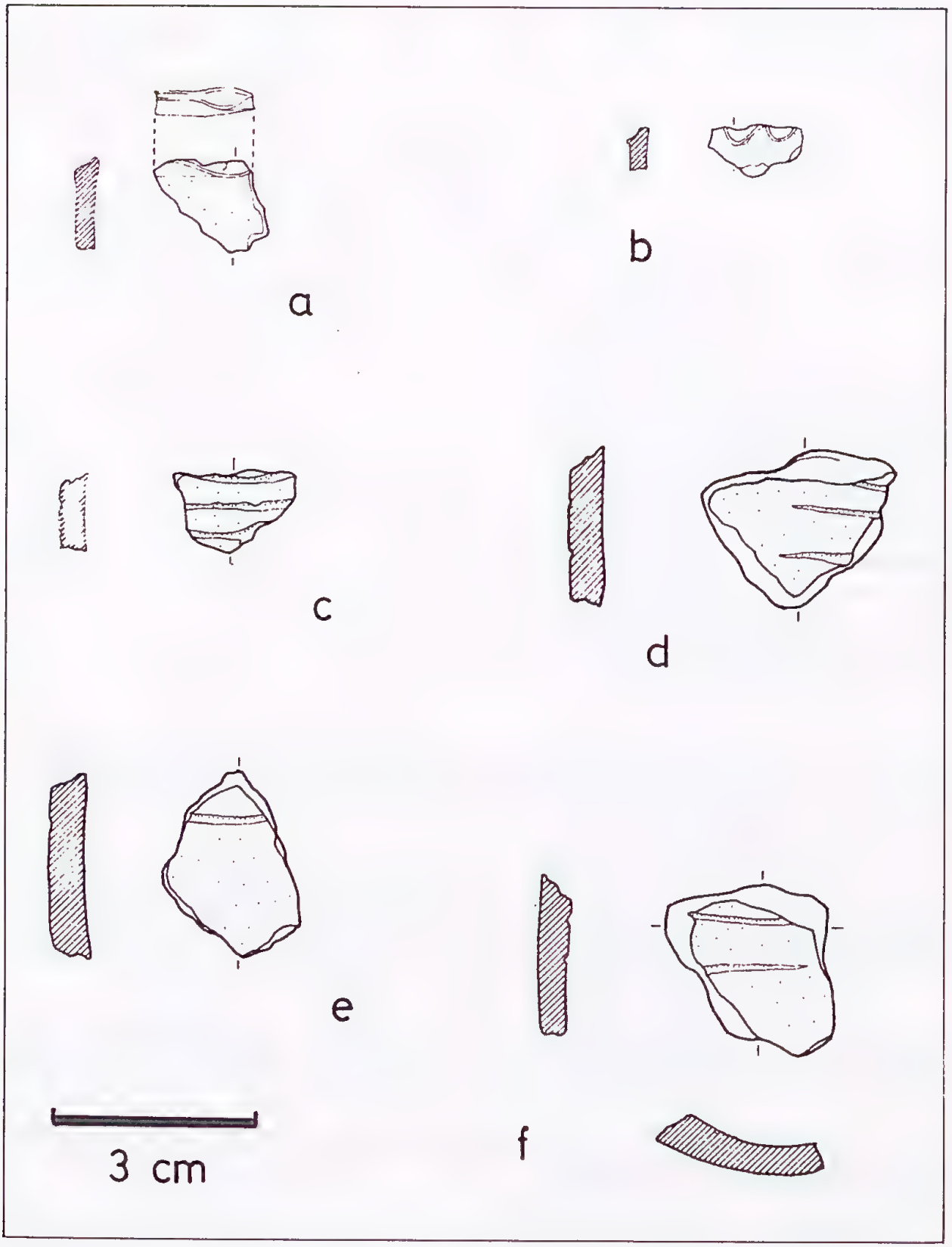

Fig. 9. Potsherds. a-b: rims; c-f: incised bodies.

Table 10. Decorated Potsherds

Ref. to Fig. 11	Location	Number of incised lines	Distance apart (mm)	Aspect	Thickness of sherd (mm)
f	D3 (3)	2	6	Interior	6
c	E5 (3)	2	3	Exterior	3
e	E5 (3)	1	—	Exterior	4
d	E4 (5)	3	4 7	? Exterior	6

III. Temper largely of black, freshly facetted volcanic sands, along with some white sand. Black sand is not present in the area and the sherds or temper may derive from elsewhere.

Clay's groups I and II are similar to the Balof A and B sherd groups. Pottery of similar appearance to the Balof A group is also common among the sherds excavated at Lesu (White 1972b:309), but a detailed analysis of that material has not yet been made.

As regards decoration, linear incisions are not reported from Pinikindu and are rare at Lesu. At both these sites applied relief is the most common decorative mode, but in both cases the majority of sherds are undecorated. Crenellated rims occur at all three sites.

STONE

(i) Sources. An initial division of the non-local stones into obsidian and other stone was made. The obsidian was sent to W. R. Ambrose (Dept. of Prehistory, Australian National University) for sourcing as part of his project on obsidian sources within Melanesia. Samples of all other rocks from the site were idenified by D. McColl, Curator of the Bureau of Mineral Resources Museum, Canberra. The probable sources of rocks thus identified were distinguished by P. D. Hohnen, who has carried out geological surveys of New Ireland for the Bureau of Mineral Resources. The results of these identifications are given in Table 11.

Group 1. Rocks in this group have not been found in New Ireland. They form 9.0% of the total non-local rock weight recovered.

(a) Obsidian (2.8%). Forty six pieces of obsidian have been subjected to the technique of prompt nuclear analysis by W. R. Ambrose (Ambrose 1977; Bird and Russell 1977). Preliminary attributions as to provenance have been made on the basis of results for Na440, Al 1013 and F, and we are most grateful to Mr. Ambrose for the early release of these attributions. Table 12 shows that obsidian from levels VI and VII is all from Talasea, and that this source continues to supply stone throughout the site's history, but is supplanted in importance by Lou Is. (in the Admiralty Is. group) in levels IV-II.

(b) Coloured and black cherts and chalcedonies (6%). Hohnen found only grey and white chalcedonies on New Ireland and considers that these coloured varieties are unlikely to be from the island. Probably they are from New Britain. However, since these rocks are vein-or cavity-filling deposits a precise sourcing is impossible without minerological analyses like those done by Ward and Smith (1974).

Table 11. Rock Materials And Probable Sources

SOURCE		ROCK	Weight in grams LEVEL I	II	III	IV	V	VI	VII	VIII	TOTAL EACH ROCK / % EACH ROCK
1. Not found on New Ireland	(a) Lou Is. and Talasea	Obsidian	3.1	2.6	6.3	1.6	2.1	8.4	20.1	—	44.2 / 2.8
	(b) Source not located	Black chert with a chalcedony vein	—	—	—	—	—	17.6	4.0	—	21.6 / 1.4
		Coloured cherts & chalcedonies	—	—	—	—	—	15.0	31.5	25.0	71.5 / 4.6
	(c) Islands to the northeast	Pumice	—	0.7	1.0	—	—	—	—	—	1.7 / 0.1
		Flow Basalt	—	—	0.2	0.9	—	—	—	—	1.1 / 0.1
2. New Ireland	Altered volcanics — not characteristic of any particular location	Grey & White cherts & chalcedonies	—	—	1.9	—	4.4	1.9	28.7	9.5	46.4 / 3.0
		Lightly altered Lava	—	—	20.3	3.7	—	—	13.7	2.6	40.3 / 2.6
		Agate	—	—	—	—	—	5.6	—	6.9	12.5 / 0.8
		Jasper & Jasperized Volcanics	—	—	—	1.2	—	7.4	15.3	34.3	58.2 / 3.7
		Altered Andesite	31.7	—	1.5	9.3	7.3	49.9	66.6	19.0	185.3 / 11.9
		Flow Rhyolite	0.3	—	—	—	—	—	3.9	12.3	16.5 / 1.1
		Basalt or Dolerite	—	—	4.1	—	—	—	7.6	—	11.7 / 0.7
		Volcanic Agglomerate	—	—	—	—	—	29.1	—	—	29.1 / 1.9
		Acid Volcanic Rhyolite	—	—	4.1	—	—	—	—	25.7	29.8 / 1.9
		Silicified Chloritised Volcanics	—	—	20.7	1.1	14.7	42.5	74.1	20.2	173.3 / 11.1

Table 11. Rock Materials And Probable Sources

SOURCE		ROCK	Weight in grams LEVEL I	II	III	IV	V	VI	VII	VIII	TOTAL EACH ROCK / % EACH ROCK
3. Specific locations within New Ireland	(a) West or South	Microgabbro dolerite	8.6	—	—	56.9	—	31.2	92.9	6.6	196.2 / 12.6
		Microdiorite	—	—	2.9	8.1	10.0	3.3	4.6	97.5	126.4 / 8.1
	(b) Central Lelet Plateau	Lithic Tuff	2.3	—	—	—	3.4	5.2	10.3	26.2	47.4 / 3.0
		Scoria	—	—	—	—	—	0.5	—	—	0.5 / 0.1
		Laterite	—	—	0.7	0.7	2.0	11.4	17.6	—	32.4 / 2.1
		Ochre	—	—	—	—	—	—	9.8	—	9.8 / 0.6
		Ochreous Claystone	—	—	—	—	—	1.2	—	—	1.2 / 0.1
	(c) Limestone plateau	Fine-grained Sedimentary	—	2.6	—	8.4	1.2	31.3	42.1	4.8	90.4 / 5.8
		Travertine	—	—	—	—	—	—	—	30.2	30.2 / 1.9
		Limestone mail	6.5	—	11.5	1.7	0.6	7.1	—	17.8	45.2 / 2.9
		Fossilized material Calcite	—	—	—	—	55.8	69.1	3.4	—	128.3 / 8.2
4. Unidentified			—	—	—	—	105.0	—	6.4	—	111.4 / 7.1
TOTAL WEIGHT — Rocks in each level in gms			53.0	4.8	74.9	93.6	206.7	337.7	452.6	338.6	1561.9
% of rocks/level			3.4	0.3	4.8	6.0	13.2	21.6	29.0	21.7	

(c) Pumice and flow basalt (0.2%). These rocks originate from areas of recent volcanism, and are likely to have been brought to the site along with obsidian. Alternatively, the pumice, at least, may have floated to the New Ireland coast from islands to the northeast, and been collected on the shore.

The presence of exotic raw materials in all levels suggests that exchange networks are of some antiquity in the area. It is interesting to note that the probably exotic cherts and chalcedonies occur exclusively in the lower levels, perhaps implying that that the earlier exchange networks were less source-exclusive than the later ones, which seem to have been based entirely on obsidian. Further there is at least twice the weight of exotic rocks in the lower 3 levels as compared with the upper 5, implying that the more recent exchange was on no greater scale than that which occurred earlier, prior to the introduction of pottery.

Group 2. Rocks of New Ireland origin, but which are vein-or cavity-filling deposits and hence not referrable to a particular area at present. These form 38.7% of the total weight of rock from the excavation.

Group 3. Rocks from specific areas of New Ireland (45.3%).

(a) West or South coast (20.7%). The nearest source for these materials is on the west coast, a little to the south of Balof, but a precise location cannot be determined.

(b) Central Lelet plateau (5.8%). Material from this area includes ochres and similar materials.

(c) Limestone plateau (18.8%). This area is nearest to the site but does not provide good materials for flaking.

Some idea of possible rock sources is given in Figure 1, based on data from the B.M.R. map of Papua New Guinea geology. According to Mr. J. Casey (B.M.R., Canberra) (pers. comm.) the nearest source of any rock material suitable for flaking is probably a 'window' exposing Oligocene volcanic rocks, (2 above) in the younger Lelet limestone some 10 km south of the excavation. However, this likely source has not been identified. It is sometimes the case that small-scale rock sources are below the level of 'geological visibility,' but were exploited by prehistoric peoples. Recent failure to identify such a source would be particularly understandable in New Ireland with its history of inland depopulation in the last two generations.

(ii) Ochre. Apart from two lumps of ochre in C3(7), a small piece of retouched stone from the same location is coloured red on both sides. A piece of shell from level I is coloured red on one side and may have been used for mixing powder with liquid.

(iii) Anvil (Fig. 10a). A pebble weighing 105 gm was found in E6 (5). On one of its faces a rounded concavity had been battered while the other face was bruised and pitted. Anvils are not reported from New Ireland sites but Specht (1969:264) reports them from Buka.

(iv) Ground stone. Two fragments of stone with grinding on two surfaces were recovered (Fig. 10b-c). One piece of basalt from C3 (3) weighs 4.1 gm and a piece of microdiorite from E3 (4) weighs 2.9 gm. These are the only pieces of axes recovered in the excavation. It should be noted that *Tridacna* shell adzes are common in coastal sites but none were found at Balof.

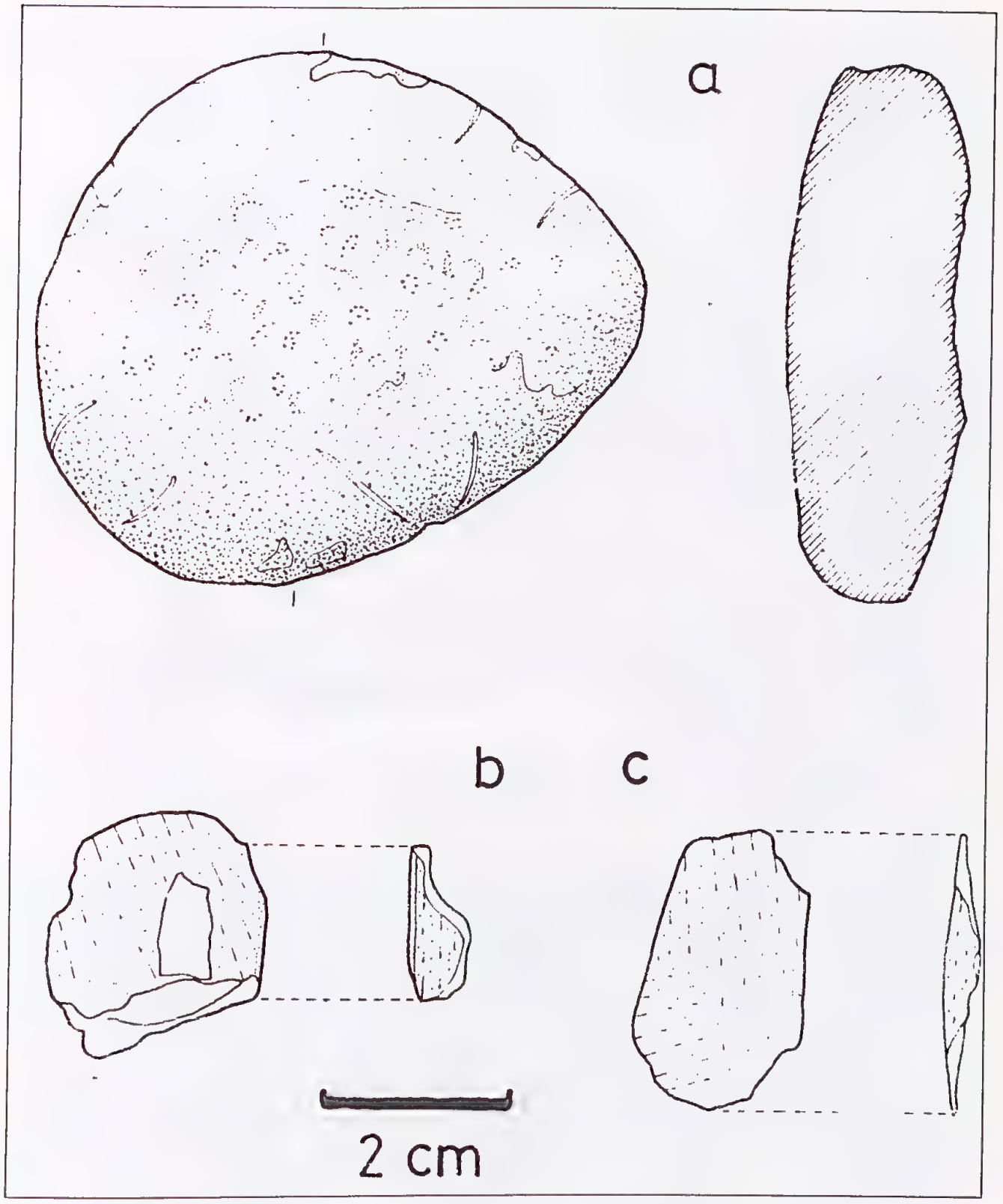

Fig. 10. Stone artefacts. a: anvil, E6(5); b-c: ground axe-adze fragments.

. (v) Flaked stone. A total of 403 pieces of stone that could be confidently identified as resulting in some way from knapping processes were excavated. Of these 46 were made of obsidian which was worked using a bipolar technique. Twenty-eight pieces, including 4 of obsidian, showed some retouch (4) or apparent use wear (24) and the remaining 331 were flakes and other knapping debris. Much of the obsidian occurred in the upper levels of the excavation but most of the other stone was found in levels VI-VIII.

Debris. The distribution of this material is given in Table 13. Over 80% of the debris occurs in levels VI-VIII. It was noted that all the coloured and grey and white cherts and chalcedonies, as well as the altered andesite (second most common variety of rock recovered) occurs among this material. No particular knapping technology could be determined from this debris.

Implements (Figs. 11, 12). Twenty-eight pieces of stone with altered edges were excavated. Step-flaked retouch occurred on only 4 stones, the rest exhibiting simply the removal of some small flakes along one or more sharp edges in a manner characteristically made by use. All the tools would normally be called 'scrapers,' but no attempt to make them in set and regular patterns could be observed. They appear to be *ad hoc* tools consisting of usable edges on pieces of stone which could be conveniently held in the hand. Their closest parallels are among the New Guinea Highlands tools described by White (1969). Many of the stones from Balof show alteration on several different edges (defined according to White 1969:24), and it is notable that all those with more than two altered edges are made on fine-grained stone.

Table 14 describes each piece of stone with one or more altered edges. The location of the alteration is given with reference to an axis drawn at right angles to the striking platform in the case of flakes, or to the longest dimension of the stone where no platform could be determined. Some indication of the size of stones is given by a surface area measurement which consists of length (defined above) times breadth, the greatest distance at right angles to this.

For the purposes of comparison, tools were grouped into two units — levels III-V and levels VI-VIII. Tables 15-17 compare weights and edges of these two groups and show no apparent differences.

Obsidian (Fig. 13). Apart from the four artefacts included in the previous section, 42 pieces of obsidian were excavated. Numbers and weights of all pieces are given in Table 18, which makes it clear that most obsidian occurred in very small pieces. About 60% of these pieces were flat flakes and exhibited battering and crushing at one or both ends (Fig. 13a). The remainder were also small flat or splinter shaped pieces, but without visible traces of working. In addition, a clearly defined bipolar or scalar core was found in E3 (7) (Fig. 13b). Both this core and the flakes are evidence for the continued use of a bipolar technique for flaking obsidian throughout the period of the site's use.

It should also be noted here that three larger flakes of obsidian were found (Fig. 13c-e). All have been used as tools and are described in Table 14, but they do not appear to have been flaked with a bipolar technique. Their occurrence in levels VI and VII, along with the absence of similar tools in higher levels, may be significant, and will be discussed further below.

In the nineteenth century obsidian was widely traded and used. Parkinson refers to trepanning, scarification and circumcision as well as wood-carving (1907 [n.d.] :104-8, 164, 166, 215), with the last use of course being likely to produce more debris. As Parkinson says, "As soon as an obsidian knife is useless, without any attempt to repair the edge, a new one is broken off. In the places where carving is done, splinters lie around in great numbers" (1907 [n.d.] :215).

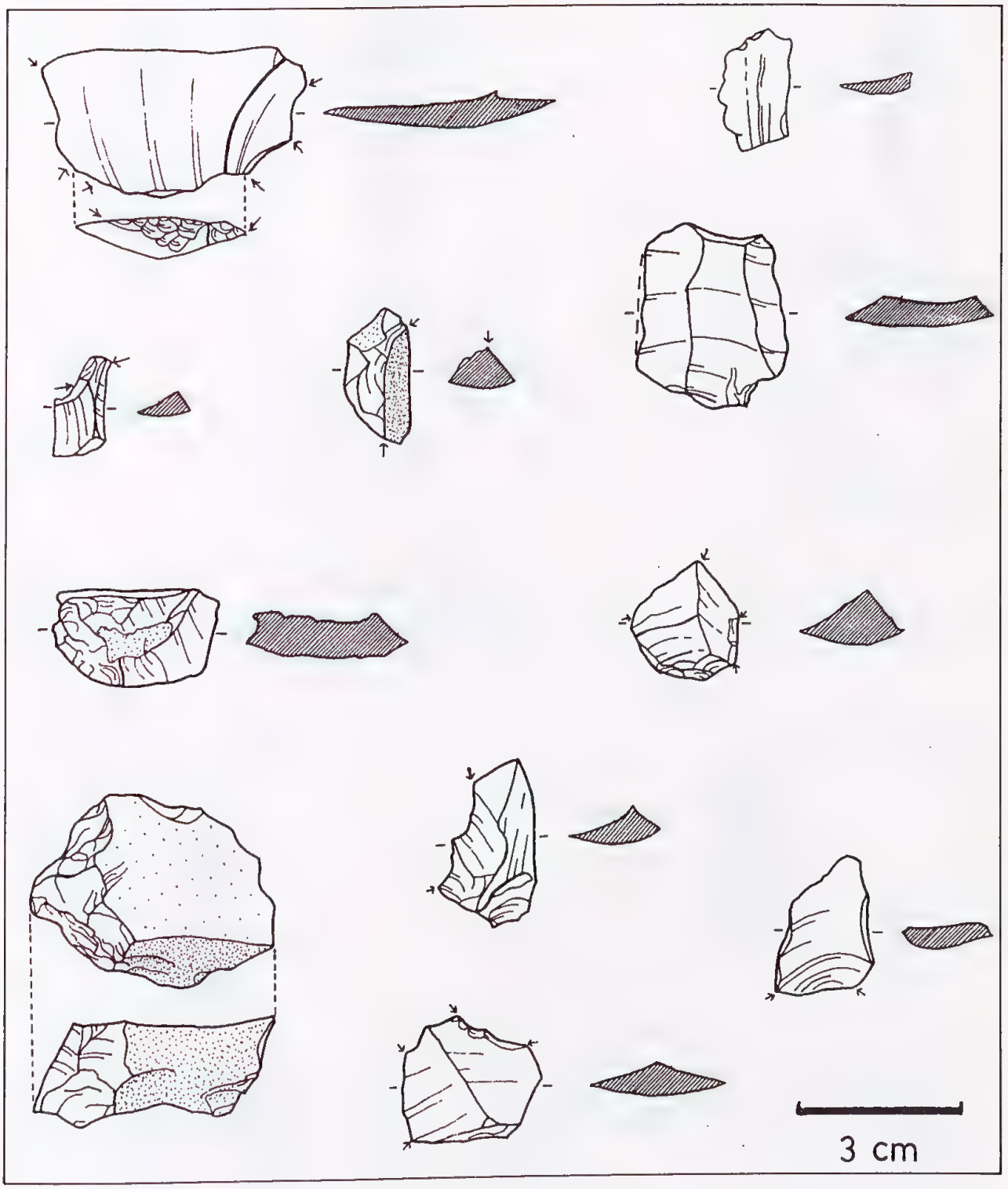

Fig. 11. Stone tools from levels VII-VIII.

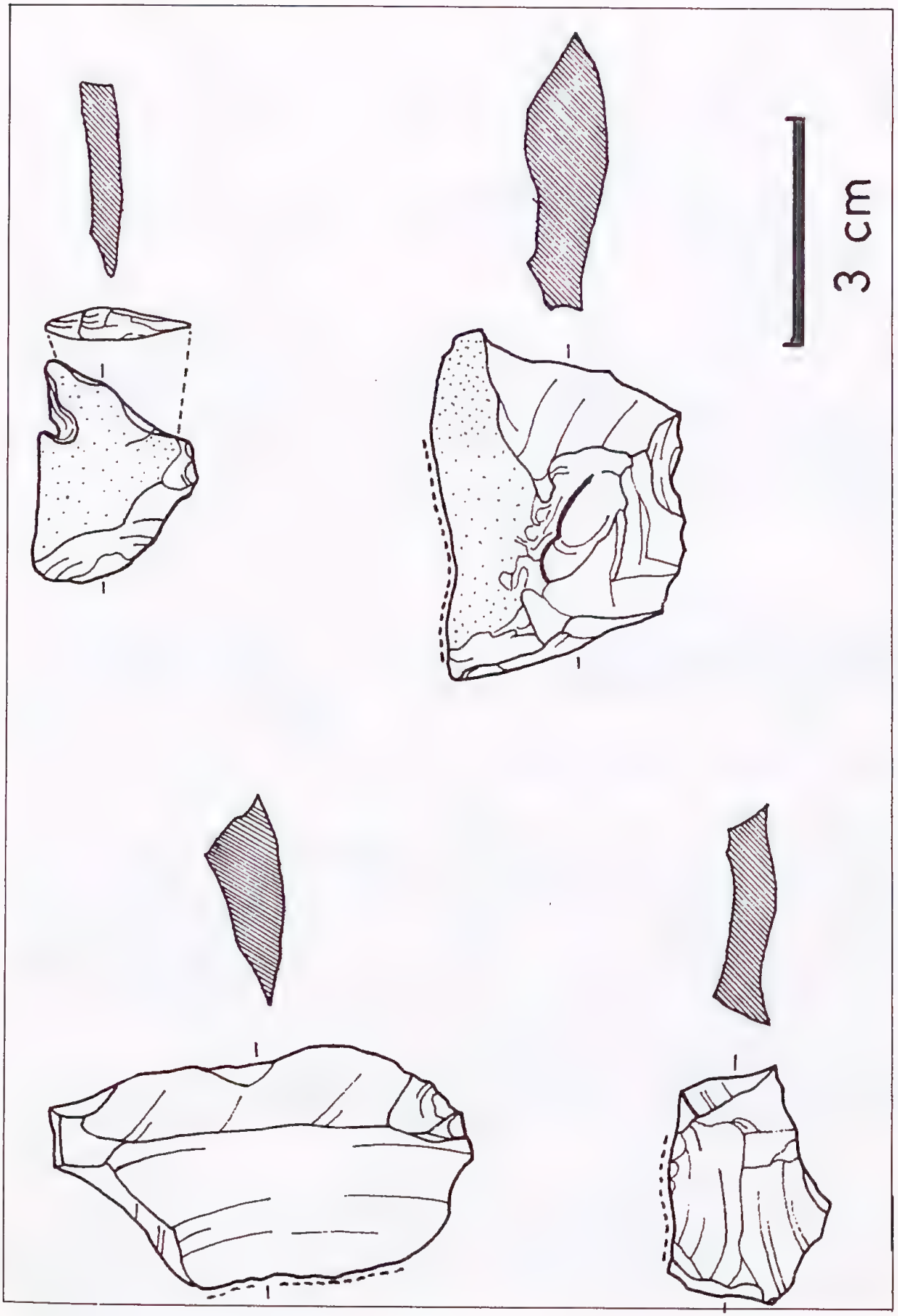

Fig. 12. Stone tools from levels III-V.

Table 12. Sources Of Obsidian (No. of pieces)

Level	Talasea	Lou Is.
I	2	1
II	1	4
III	4	11
IV	2	3
V	4	1
VI	4	—
VII	8	—
VIII	—	—

Table 13. Distribution Of Flakes Showing No Use Wear Or Retouch: Numbers And Weight (gm)

LEVELS	C3	D3	E3	E4	E5	E6	TOTALS	WEIGHT (gm)
I	1	1	2	—	—	1	5	42.9
II	—	—	—	—	—	1	1	2.6
III	—	2	—	2	—	1	5	4.7
IV	1	1	1	2	3	5	13	5.3
V	4	—	—	4	9	7	24	26.7
VI	8	7	—	10	6	13	44	155.6
VII	35	43	17	43	2	13	153	333.0
VIII	17	16	—	43	—	10	86	200.0
TOTALS	66	70	20	104	20	51	331	850.8

Table 14. Stones With Altered Edges

Level	Square	Weight (gm)	Area (sq. mm.)	Retouch	Location of Alteration	Lengths of Altered Edge (mm.)	Material
III	E3	20.3	1300		Both sides and end	27, 10, 24	Lightly altered lava or chert
	E4	20.7	1100		All edges altered	77, 20, 15, 5, 22, 18	Silicified chloritised volcanic
IV	E5	3.7	500		Side	10	Lightly altered lava
V	E3	2.6	450		Both sides and end	20, 11, 15	Calcite
	E5	7.7	500		End	15	Silicified chloritised volcanic
	E5	0.8	200		Both sides and end	10, 15, 5	Calcite
VI	C3	10.7	1050	✓	Both sides and end	30, 15, 15	Silicified chloritised volcanic
	E3	6.3	650		Multiplane	10, 15, 12, 7, 20, internal 20, 12, 4	Obsidian (Fig. 13b)
	D3	1.0	400		Both sides and end	30, 5, 20	Obsidian blade (Fig. 13c)
VII	C3	7.6	700		Both sides and end	10, 20, 6, 22, 10	Basalt or dolerite
	C3	3.7	250		Side	25	Obsidian
	C3	14.5	100		Side	20, 9	Microgabbro dolerite
	C3	2.3	400		End	5	Lithic tuff
	D3	3.1	300		Both sides and end	10, 11, 8, 30	Silicified chloritised volcanic
	C3	4.5	500		Both sides	18, 15	Fine-grained sedimentary chert
	D3	3.4	300	✓	Multiplane	15, 10, 9, 7, 10	Calcite, Fos. shell
	E3	26.8	1000	✓	Multiplane	5, 5, 20, 20, 5, 5	Fine-grained sedimentary chert
	E3	1.0	100		Side and end	3, 2	Silicified chloritised volcanic
	E4	2.4	250		Multiplane	9, 10, 10	Altered lava
	E4	7.0	450		End	13. Prob. Whole	? Flow rhyolite
	E6	2.1	250		Multiplane	12, 6, 6, 6	Tuff
	E4	11.6	700		Both sides and end	8, 17, 7, 20, 7	Obsidian (Fig. 13e)
	E6	1.0	200		Broken	10-edge not whole	Jasperized volcanic
VIII	C3	19.3	1100		Side, probably not whole	19	Microdiorite pebble
	D3	17.0	800		Multiplane	20, 21, 12	Silicified chloritised volcanic
	D3	5.6	500		Both sides	25, 20	Microdiorite pebble
	D3	.5	200		Broken	Edge not whole	Jasper
	E4	2.6	300		Side	20	Lightly altered lava

Table 15. Stones with Altered Edges: Weight (gm)

Levels	<4	4-9.9	10-19.9	>20	Total
III-V	3	1	0	2	6
VI-VIII	10	5	5	1	21

Table 16. No. of Altered Edges/Stone (%)

Levels	No. of edges								No. of Tools	Mean No.
	1	2	3	4	5	6	7	8		
III-V	33.3	—	50.0	—	—	16.7	—	—	6	2.8
VI-VIII	23.8	23.8	19.0	9.5	14.3	4.8	—	4.8	21	3.0

Table 17. Shapes of Altered Edges (%)

Levels	Straight	Concave	Convex	Wavy	No. of Edges
III-V	35.2	35.2	17.7	11.8	17
VI-VIII	50.0	29.7	10.9	9.4	64

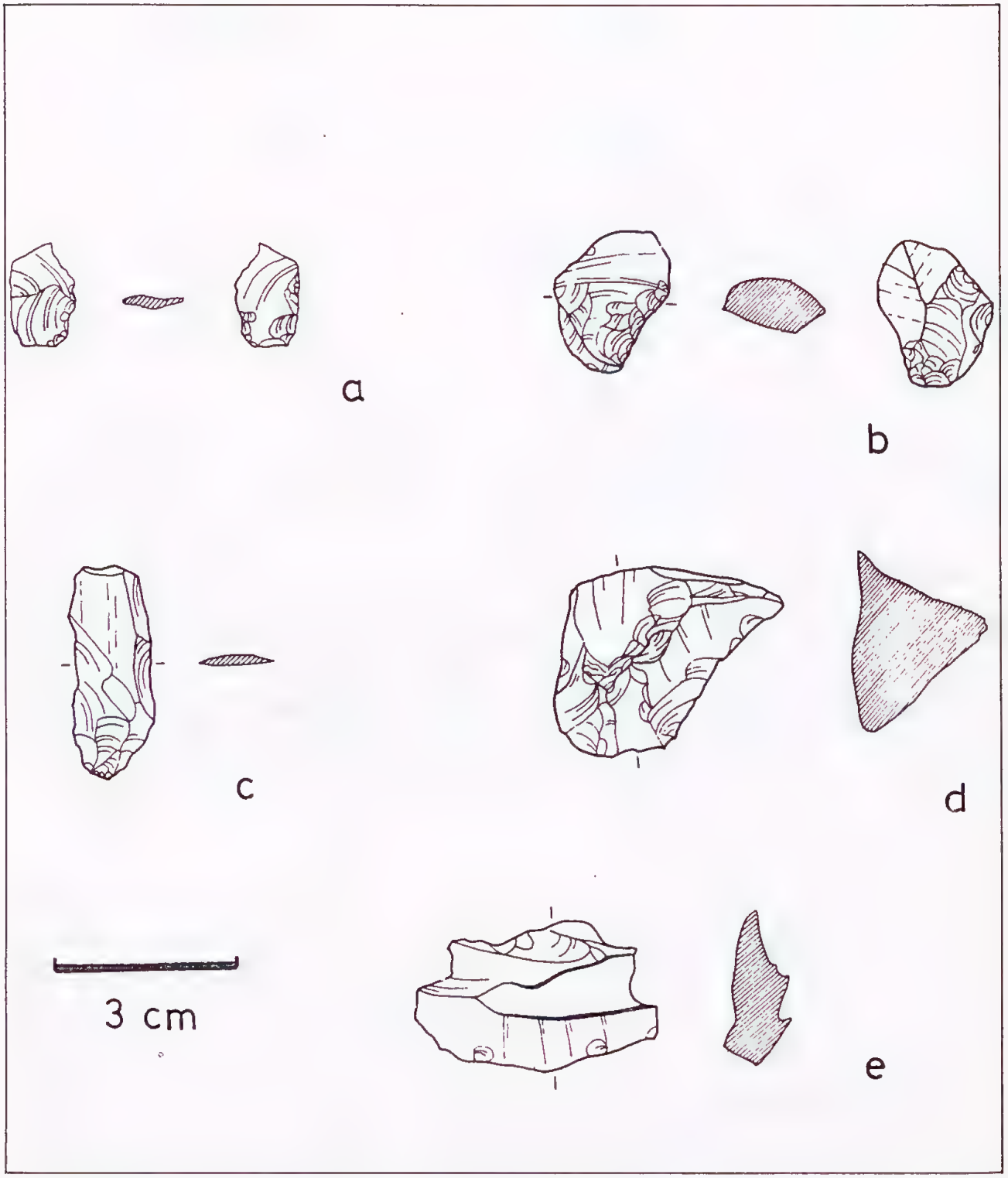

Fig. 13. Obsidian artefacts. a: typical small flat flake, C3(3); b: scalar core, E3(7); c: blade flake, D3(6); d-e: chunky flakes, E4(7), E3(6).

Table 18. Distribution of Obsidian (gm)

Each figure denotes the weight of a single piece

Levels	C3	D3	E3	E4	E5	E6	Total wgts (gm) and %	Total nos of flakes and %
I	—	2.5	0.4	0.2	—	—	3.1 7.0	3 6.5
II	0.5 0.7	—	0.3	—	0.6	0.5	2.6 5.9	5 10.9
III	0.6 0.4 0.4 0.3 0.2	0.1	0.4 0.3 0.3	1.0 0.8 0.3 0.3 0.2	0.6	0.1	6.3 14.3	16 34.8
IV	0.3	0.5 0.3 0.2	—	—	—	0.3	1.6 3.6	5 10.9
V	—	0.6 0.2	—	—	—	1.0 0.2 0.1	2.1 4.8	5 10.9
VI	—	1.0* 0.5	6.3*	0.6	—	—	8.4 19.0	4 8.7
VII	3.7* 0.2 0.2 0.1 0.1	1.2	3.0	11.6*	—	—	20.1 45.5	8 17.4
VIII	—	—	—	—	—	—	— —	— —
Totals	13	10	7	8	2	6	44.2 100	46 100

* Marks a piece with altered edges or a core

4. DISCUSSION

STRATIGRAPHY AND THE SAMPLE

In the preliminary report on Balof, it was suggested that there were two main levels, an upper marked by bone points, pottery and obsidian, and a lower with a wider range of retouched tools made of stone other than obsidian (White 1972b). This report shows that a simple division into two stages cannot be maintained, although as Table 19 shows there are clear changes through time in the artefactual content. Within levels IV-V, several items were added to the inventory, one at least was dropped and there was a change in the nature and quantity of worked stone.

It is possible that the changes at Balof all occurred at a particular time, but various taphonomic processes have combined to obscure this. For example we might expect that not every kind of new item brought into the area would be carried to the site and immediately deposited there. Then, too, it is also clear that the accumulation of deposit at Balof was slow(*w*15mm/100 yrs.), and there must have been some re-working of it by both casual and deliberate human activities. The absence of visible hearths and pits other than near the surface, along with the uniform texture of the soil is adequate witness to this. It must therefore be considered whether we should regard levels IV and V, and perhaps even III and VI, as "mixed." As Stockton (1973) has shown in other conditions, small objects tend to move downward in some kinds of deposit while larger ones move upward. Should these processes be used to explain the obsidian chips and bone points in the lower level, and the larger pieces of altered local stone in the upper? If we took the interface of levels V and VI as the transition point, this would imply the downward displacement of some 13 pieces of obsidian (25% of the total), including the five *largest* pieces, and 12 bone points (45% of the total), as well as the upward displacement of six stone tools (20%). This would have occurred in a deposit which was not dry, fine sand but a slightly damp, fairly fine soil, reasonably well packed and containing large quantities of shell and bone. In the light of Stockton's (1973) data and Matthews' earlier discussion (1963) we are reluctant to believe in such large-scale resorting of artefacts in this deposit, while recognising that some has certainly occurred. In particular we suggest that much of the lower obsidian and most of the upper stone tools are in a relatively correct stratigraphic and thus chronological relationship. The implications of this will be discussed below.

Further, we draw attention to the fact that only 6 square metres have been excavated from a site which, if it stretches over the entire sheltered area, will be some 100 m^2 in extent. Given that different parts of a site are likely to be differently used, and that rubbish deposition areas in odd corners may be less disturbed by subsequent activities, we see further excavations as having some potential not only for finally resolving the displacement problem just discussed but also, perhaps, for isolating different areas of site use.

In conclusion, we note that the common occurrence of shells and land animal bone throughout the deposit suggests the presence of both females and males, but that most of the artefacts, the uses of which are inferred from ethnographic data, were probably used by men (bone points, stone axes) or are not sex-linked, at least in the form in which we find them (obsidian flakes, shell tools, arm-rings).

FAUNA

The sample of faunal material from the site is too small for any major conclusions to be drawn. It is interesting to note that fish remains occur only in level V and above, while it is in level IV and above that shellfish derive from a wider range of environments, including the reef and lagoon. These changes hint at some economic re-orientation,

Table 19. Summary of Excavated Material

Levels	Arm-ring	Pig bones	Fish bones	Ground Stone	Pottery	Shell tools	Obsidian	Shark teeth	Bone points	Prob. imported chalcedony	Bone pendant
I	—	✓	✓	—	✓	✓	✓	—	—	—	—
II	✓	✓	✓	—	✓	✓	✓	✓	—	—	—
III	✓	✓	✓	✓	✓	✓	✓	—	—	—	—
IV	—	✓	✓	✓	✓	✓	✓	✓	✓	—	—
V	—	—	✓	—	✓	✓	✓	✓	✓	—	—
VI	—	—	—	—	—	✓	✓	—	✓	✓	—
VII	—	—	—	—	—	✓	✓	✓	✓	✓	✓
VIII	—	—	—	—	—	—	—	✓	✓	✓	—

possibly associated with the observable artefactual changes, but we cannot be more definite. There is no diminution in the numbers or range of land-based animals, and remains of the only animal not now present on the island (*Macropus agilis* or *Dendrolagus* sp.) occur in upper levels, so that the site must have been a base for cooking hunted animals throughout its history. The occurrence of pig in levels IV and above only may be significant. Pig is commonly associated with first millennium B.C. settlements in island Melanesia (Green 1976) and was, of course, introduced to mainland New Guinea long before this (White 1972a; Bulmer 1975). It is possible that pigs were brought into island Melanesia only by the widespread exchange network associated with dentate-stamped 'Lapita' pottery and obsidian (Green 1976), but more data from sites older than the second millennium B.C. are required to determine this.

POTTERY

Although some general similarities can be seen between the sherds found at Balof and those from other New Ireland sites, the amount of material is too small for detailed comparative analyses. This also affects any discussion of the relation between the pottery at Balof and either the Lapita pottery complex (Green 1974) or the 'Sohano style' of pottery found on Buka and Sohano Islands (Specht 1972). Given that pottery appears at Balof probably around 2000-2500 years ago and similar ceramics occur at other sites in the same area (Clay 1974; White 1972b), and remembering that in this region classic 'Lapita style' pottery has been found only on small islands to the north and south of New Ireland (Egloff 1975; White and Specht 1971), we are inclined to think that New Ireland pottery is a local development, perhaps by some kind of "stimulus diffusion" from Lapita-style pottery makers. It is already clear that there is a complex relationship between 'classic' Lapita and more local pottery traditions in the New Hebrides (Garanger 1971) and the Solomons (Specht 1972): we suggest a similar situation occurred in New Ireland, though without yet being able precisely to define the nature of the relationship.

STONE

The stone artefacts from Balof are interesting for two reasons — technological and material. Technologically two different flaking processes occur concurrently. While most of the obsidian is flaked with a bipolar technique, other stone is knapped in a more *ad hoc* fashion. The latter seems to be common to New Guinea, Melanesia and beyond (White 1969) and probably represents the original form of stone tool use in the area.

Bipolar flaking will produce a larger number of small sharp-edged pieces from a small piece of stone than will other techniques, particularly if the core is wrapped so that the force of the hammer below is cushioned and directed downwards (White 1968). The flakes at Balof may appear too small for use, but JPW has observed flakes of similar size, held between thumb and forefinger, used frequently for carving in the New Guinea Highlands (see Lampert 1971 also).

Bipolar techniques have been noted by JPW in the obsidian exchanged throughout Melanesia in the first millennium B.C., but no thorough examination has been made of the technologies used on this material at any location. The multitude of small flat flakes found at Balof are paralleled at Lesu (New Ireland), Ambitle Is., and the Reef Islands sites and we suggest that the use of this flaking technique is linked to the rarity of obsidian and the consequent need for economy in its use.

Overall, the changing pattern of stone resources drawn on at Balof is an important one. First, we note that in the earlier levels all obsidian came from the Talasea source on New Britain, some 600 km of coastal travel distance. This early obsidian was not always flaked in the most economical way; as a few larger, non-bipolar pieces show. In the

earlier levels too, the presence of a range of other rock types whose sources probably lie at some distance away, on or off the island, points to a wider network of resource exploitation than occurs later. It seems likely that this network of stone exchange, which existed from some 6000 years ago formed the structural basis upon which the better-known exchange systems of the first millennium B.C. were erected.

By about the first millennium B.C. — Balof data does not allow us to be very precise in dating — it is notable that stone other than obsidian has become much scarcer and the obsidian itself comes mostly from Lou Island, in the Admiralty Islands group. This source, although closer to Balof (480 km), lies on the other side of a 175 km direct sea crossing, and it is not surprising to find its exploitation developed later in time. Other sites in the region (e.g., Watom) show that the Talasea source continued to be exploited in this period, and a few pieces were traded as far as Balof. All obsidian in these levels is flaked with a bipolar technique.

We also draw attention to the fact that stone other than obsidian was almost completely absent from the Lesu site, dated probably to 1500-2500 B.P., and most (all?) obsidian there was flaked with bipolar technique. The consistent data from these two sites encourages us to think that exchange networks were more highly integrated and specialised in the first millennium B.C. than they had been earlier. We predict, on the basis of this reconstruction, that the majority of obsidian at Lesu will be found to be of Lou Is. origin.

CONCLUSION

The 6 m^2 excavation at Balof has demonstrated the human settlement of New Ireland probably some time in the fifth millennium B.C. The presence of humans in island Melanesia at this time has previously been predicted on the basis of the occurrence of Non-Austronesian languages, and surface finds of apparently "old" stone tools (Shutler and Marck 1975; Shutler and Kess 1969), but no dated archaeological site had been located. Balof is such a site.

The material excavated demonstrates, to a limited degree, that whereas early inhabitants drew on a wide range of stone sources (including Talasea obsidian), hunted land animals (one to extinction?), and collected most shellfish from a particular environment, later users were in possession of pottery and also made use of a wider variety of marine resources, but drew on a narrower range of stone resources, particularly Lou Is. obsidian. Small bone bipoints may be linked to hunting or to some activity no longer current, but whether arm-rings, ground stone axes and the possession of pigs are all restricted to the later users remains to be determined by research on a larger scale.

ACKNOWLEDGEMENTS

The excavation reported here was carried out by JPW in April-May 1969, as part of a project to survey the prehistoric resources of New Ireland and in particular to discover evidence of pre-ceramic inhabitants. The project was funded by the Australian Research Grants Committee, and The Australian Museum allowed JPW time from other duties to undertake this research. A preliminary sorting of the material in 1970-71 allowed the preparation of a brief report (White 1972b). A more complete study of all the material was undertaken by JED in 1975-6 and a full analysis and report was presented to the University of Sydney as a Master of Arts thesis in 1976. This paper has been written largely from the thesis.

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